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William Healey Dall.
My way is the way for me.
COMPARATIVE ANATOMY.

BY

C. TH. V. SIEBOLD AND H. STANNIUS.

TRANSLATED FROM THE GERMAN,

AND

EDITED WITH NOTES AND ADDITIONS

RECORDING THE

RECENT PROGRESS OF THE SCIENCE,

BY

WALDO I. BURNETT, M.D.

VOLUME I.

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ANATOMY
OF THE
INVERTEBRATA.

BY
C. TH. V. SIEBOLD.

BOSTON:
GOULD AND LINCOLN,
55 WASHINGTON STREET.
1854.
To

MY ESTEEMED FRIEND,

LOUIS AGASSIZ,

PROFESSOR OF ZOOLOGY. &c.,

IN

Harvard University,

WHOSE WELL-KNOWN RELATIONS TO COMPARATIVE ANATOMY REQUIRE NO MENTION HERE, AND WHOSE SPLENDID GENIUS HAS DONE SO MUCH TO AWAKEN, IN THIS COUNTRY ESPECIALLY,

A LIVELY INTEREST IN OBJECTS OF NATURAL HISTORY,

I Inscribe this Volume,

WITH ADMIRATION AND SINCERE GRATITUDE.

WALDO I. BURNETT.
NOTICE OF THE TRANSLATOR AND EDITOR.

In issuing an English translation of the Lehrbuch der vergleichenden Anatomie of Von Siebold and Stannius, any formal account of the work is quite unnecessary. To all Anatomists it is a treatise already well and favorably known, and it has justly been regarded as the most complete and comprehensive work of its kind now extant in any language. The high position and distinguished reputation of its authors have been fully sustained by this portion of their labors.

But there are several features in this work which should be mentioned, since by them it is favorably distinguished from all other treatises of the kind that have preceded it.

In the text will be found a lucid yet succinct exposition of the anatomical structure of organs, arranged as far as practicable under distinct types. The details on which this typical summary is based, are comprised in notes which are as remarkable for their erudition as for their copiousness; indeed, the utmost care has been taken in the literature of the various subjects treated, and the student will here find the most reliable and at the same time the fullest reference to the bibliography of nearly every subject in Comparative Anatomy. In this way, the work as a whole furnishes a complete dictionary of the science, and will prove invaluable even as a work of suggestion and reference, to those who would pursue any special line of inquiry and research in this department.

It may be truly said that the Microscope lies at the foundation of all our best knowledge of anatomy, and especially that of the Invertebrata. This is the case, not only on account of the small size of most of the animals, but because, as Von Siebold has said in his preface, the anatomy of these lower forms is scarcely reliable unless based upon histological investigations.
Hence, that part of the work treating of the anatomy of the Invertebrata, by Von Siebold, is rich in the results of microscopical researches; and their value in the elucidation of the subject will be readily appreciated. This plan of procedure has not the same urgency with the higher animals, where the character of an organ or part can generally be ascertained from its position, &c.; and, in the second part of the work, on the Anatomy of the Vertebrata, by Stannius, details of microscopical structure are comparatively little insisted upon. But, within a few years, the histological composition of organs, even though their character and function is well known, has become of great and increasing interest; and details of this kind, as far as they would be understood without the aid of figures, I have sought to add in their regular order and place.

As to the notes and additions generally, they stand by themselves with Ed. affixed, and almost invariably refer to some point treated of in the text or notes of the original, and for the most part relate to the correction, confirmation, or extension of some statements there made. These notes were drawn from all the sources accessible to me; but from the many difficulties in the way of the early receipt of foreign works in this country, they are not as complete a record of the recent progress of the science as would be desired.

As to the translation, I may say, that not being a German scholar, but having read the German language chiefly for scientific purposes, I trust that any inelegances of diction or idiom will be excused. But, throughout, I have endeavored to give a faithful rendering of the author's meaning, and to express this in as simple and terse a form as possible.

In conclusion, I wish to express my gratitude to my friends who have kindly aided me in this work; — prominent among these is Mr. Edward Capen of this city, who has been of invaluable assistance to me in the labor of passing the sheets of this volume through the press: — of others, such as Professors Agassiz, Dana, Leidy, and Wyman, their names will be found honorably recorded by their own important labors in science, to which I have so frequently referred in these volumes.

Boston, Nov. 1853.
As latterly, Zootomists have given much greater attention to the invertebrate animals than formerly; and as, with these investigations they have united, as much as possible, others upon the generation and development of these animals, such a mass of material, composed, in part, of entirely new and very remarkable facts, has accumulated, that the manuals of Zootomy hitherto published are of a scale quite inadequate to receive them. It is unnecessary, therefore, for me to offer further reason for the task I have undertaken of arranging these materials and reducing them to a systematic form. But the order in which I have disposed them may not meet with general approval, for, hitherto, in works of comparative anatomy, the organs, and not the zoological classes, have served as the basis of the order pursued.

But, in the present state of Science, and at least provisionally, it appears to me that the anatomical order should not be followed, for, the types, which, until now, have been recognized in the developmental series of the several organs, appear no longer valid and permanent. Indeed, extended researches made upon a great number of animals, have shown that these types, hitherto regarded as expressive of fundamental laws, may almost be taken as the exceptions. Such genera as *Hydra, Lumbricus, Hirudo, Unio, Astacus,* &c., can now no longer be regarded as the representatives of certain animal classes or orders, for their organization is far from affording the requisite type of that of allied animals. It appears now clearly determined that the types of the development and disposition of the various organs of the Invertebrata are more numerous and varied than hitherto supposed, and that, in this respect, a rule wholly different from that of those of the Vertebrata must here be applied. But as the numberless details which we now possess upon the organization of the Invertebrata, have not been thoroughly worked out and systematized in all the orders, it is really a task too difficult to here distinguish the rule from the exception, and the type from that which is only a secondary modification.
I have especially devoted myself to the collecting and collating as completely as practicable, the numerous new and important facts in the organization of the invertebrate animals, which have as yet been developed. And as occasion presented, I have verified with my own eyes the particular results; and when I have been obliged to refer to the discoveries and observations of others, I have cited exactly their works.

I could not exclude Embryology and Histology from this work, for, in these branches, often lies our only means not only to ascertain the true nature of many larval forms among the lower animals, but also to arrive at the correct interpretation of many organs which, in form, position, and arrangements, have no analogues among the higher animal forms. It is only by the aid of Histology that we are able to show that this or that organ is a branchia, a liver, a kidney, an ovary, or a testicle; while, in the Vertebrae, which are organized after a few principal types, the signification of most of the organs can usually be easily determined by their position and connection.

In order to avoid long descriptions, I have, when practicable, referred to plates and figures; but in so doing I have always endeavored to cite the good and original representations, for I am convinced that many figures which are transferred from one book to another, become, at last, so changed as to be quite dissimilar to the original.

The elaboration of this work having been commenced in 1845, but its completion having been delayed by my change of residence from Erlangen to Freiburg, and partly by a pretty long sojourn of mine on the Adriatic Sea, I have been unable to use the important works which have been published during the last few years, except in the form of a Supplement [additional notes] which will serve to complete, to confirm, or to rectify what has been advanced in the body of the work.

I take this opportunity to publicly express my gratitude to A. Kölliker, H. Koch, A. Krohn, C. Vogt, and H. Stannius, for the friendly and important aid they have rendered me in the completion of this difficult task — not only by the transmission to me of interesting and rare marine animals, but also in the communication of important manuscripts and letters, the contents of which they have allowed me to freely use for my work.

Freiburg (in Breisgau), Feb. 27, 1848.

C. Th. v. SIEBOLD.
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CLASSIFICATION
OF THE
INVERTEBRATE ANIMALS.

§ 1.

The invertebrate animals are organized after various types, the limits of which are not always clearly defined. There is, therefore, a greater number of classes among them than among the vertebrates. But, as the details of their organization are yet but imperfectly known, they have not been satisfactorily classified in a natural manner.

There are among them many intermediate forms, which make it difficult to decide upon the exact limits of various groups.

The following division, however, from the lowest to the highest forms of organization, appears at present the best:

ANIMALIA EVERTEBRATA.

INVERTEBRATE ANIMALS.

Brain, spinal cord, and vertebral column, absent.

FIRST GROUP.

PROTOZOA.

Animals in which the different systems of organs are not distinctly separated, and whose irregular form and simple organization is reducible to the type of a cell.

CLASS I. INFUSORIA.
CLASS II. RHIZOPODA.

SECOND GROUP.

ZOOPHYTA.

Animals of regular form, and whose organs are arranged in a ray-like manner around a centre, or a longitudinal axis; the central masses of the nervous system forming a ring, which encircles the oesophagus.

CLASS III. POLYPT.
CLASS IV. ACALEPHÆ.
CLASS V. ECHINODERMATA.
THIRD GROUP.

VERMES.

Animals with an elongated, symmetrical body, and whose organs are arranged along a longitudinal axis; so that right and left, dorsal and ventral aspects may be indicated.

The central nervous mass consists of a cervical ganglion, with or without a chain of abdominal ganglia.

CLASS VI. HELMINTHES.
CLASS VII. TURBELLARII.
CLASS VIII. ROTATORII.
CLASS IX. ANNULATI.

FOURTH GROUP.

MOLLUSCA.

Animals of a varied form, and whose bodies are surrounded by a fleshy mantle. The central nervous masses consist of ganglia, some of which surround the oesophagus, and others, connected by nervous filaments, are scattered through the body.

CLASS X. ACEPHALA.
CLASS XI. CEPHALOPOURA.
CLASS XII. CEPHALOPODA.

FIFTH GROUP.

ARTHROPODA.

Animals having a perfectly symmetrical form, and articulated organs of locomotion. The central masses of the nervous system consist of a ring of ganglia surrounding the oesophagus, from which proceeds a chain of abdominal ganglia.

CLASS XIII. CRUSTACEA.
CLASS XIV. ARACHNIDA.
CLASS XV. INSECTA.

BIBLIOGRAPHY.

§ 2.

Besides the various ancient and modern works upon general comparative anatomy,—such as those of Blumenbach, G. Cuvier, F. Meckel, E. Home, Blainville, Delle Chiaje, Carus, Grant, Rymer Jones, Strauss

1 Handbuch der vergleichenden Anatomie. Göttingen, 1824.
6 Istituzioni di Anatomia e Fisiologia Comparata. Napoli, 1832.
7 Lehrbuch der vergleichenden Anatomie. 2nd ed. Leipzig, 1834.
§ 2. Bibliography.

Dürecbein, (10) R. Wagner, (11) there exist various contributions upon the relations of these animals in the physiological works of Treverinus, (12) Rudolph, (13) Dugès, (14) Burdach, (15) J. Müller, (16) R. Wagner, (17) and in the Medical Zoology of Brandt and Ratzeburg. (18)

The iconographic illustrations by Carus and Otto, (19) and by R. Wagner, (20) contain many plates representing these animals; and in Guerin's Iconographie, (21) and Cuvier's (22) Régne Animal, edited by several French naturalists, are many illustrations of their internal structure.

The following are some of the anatomical works which treat specially upon these animals:

Schweigger. — Handbuch der Naturgeschichte der wibellosen ungegliederten Thiere. Leipzig, 1820.


A second and enlarged edition of this memoir has been published under the following title: Deserizione e notomia degli animali invertebrati della Sicilia citeriore. 1-5, vol. Napoli, 1841. Con tavol. I.-GLXXII.


These same naturalists have prepared the second part of Wagner's Lehrbuch der Zootomie, under the special title of: Lehrbuch der Anatomie der wibellosen Thiere. Leipzig, 1847.


11 Lehrbuch der Zootomie. 2nd ed., entirely revised; or "Lehrbuch der vergleichenden Anatomie." Leipzig, 1842.
16 Handbuch der Physiologie des Menschen. 2 vol. 4th edit. Coblenz, 1844.
17 Lehrbuch der Physiologie. 2nd edit. Leipzig, 1843.
19 Erörterungstafeln zur vergleichenden Anatomie. 6 heft. Leipzig, 1836-35.
21 Iconographie du Régne Animal de G. Cuvier, en Représentation d'après nature de l'une des espèces les plus remarquables et souvent non encore figurées de chaque genre d'Animaux; pour servir d'atlas a tous les Traitées de Zoologie. 7 vol. avec 450 planches. Paris, 1836-38.
INTRODUCTORY NOTE TO THE INFUSORIA.

Constant labors in the whole department of microscopy, and that, too, with greatly improved instruments, during the past few years, have materially changed the face of the class Infusoria since the issue of this work. There have been numerous and signal researches among all the lower forms of animal life; and the imperfect and undeveloped forms of others, which are higher, have been wrought out with an accuracy and detail before unknown.

These movements have all tended to diminish the numbers of the so-called Infusoria, and it remains to be seen how large the proper class will be when these researches shall have been further extended. By some even it is believed that it will be entirely resolved into other classes; this view, however, would appear far from being warranted by our present knowledge; for, while, on the one hand, whole genera have been shown to be only larval worms (Bursaria, Paramaecium, &c., from Planaria),* yet, on the other, some forms have manifested phenomena and changes leading us to place them almost unhesitatingly among individual animals. In its best aspects, however, the subject has many perplexing points; and, in its present unsettled state, it is almost hazardous for a scientific man to entertain anything like positive views thereon.

I need scarcely allude to the vegetable, algous character which whole sections of the Polygastrica have recently assumed; and the limits of this work will not allow me to discuss in detail this and other interesting points. But there are two or three topics of the highest physiological import, which are prominently introduced by these studies. These are, What is a plant? What is an animal? and, Are the animal and vegetable kingdoms on their lowest confines separate and distinct from each other?

As is well known, all the older criteria by which animals were separated from plants have long since been regarded invalid; and some of those which in late years have been regarded among the most constant, have, quite recently, been declared as equally unsound. Cellulose has been shown to be a component of animal as well as of vegetable structures, and Kölliker† has insisted that some forms which have neither mouth nor stom-

†Kölliker, Siebold and Kölliker's Zeitseh. I. 1849, p. 198.
ach, but consist of a homogeneous mass, are true animals. If these premises are correct, nothing will remain, as I conceive, for a distinctive characteristic, but voluntary motion. This, when positive, is indubitable evidence of any given form being of an animal character; and it must remain for each individual observer to determine what is, and what is not, voluntary action, in each particular case. Moreover, even should Kolliker's view of a stomachless animal prove correct, the inverse condition of a true stomachal cavity being present, must, I think, be regarded as positive evidence of the animal nature of the form in question; for this must always be a distinctive characteristic of the two kingdoms, when present.

In regard to the other point, What constitutes an animal? observers are very far from being agreed. Siebold, Kolliker, and others, have taken the ground that individual animal forms may be unicellular; or, in other words, that an animal may be composed of only a single cell.* This view is principally due to Kolliker's observations and statements upon Gregarinae.† The facts are indeed striking, but the evidence does not appear to me sufficient, as yet, to settle such a vexed and important question; and more especially so since Bruch‡ has raised the point of their belonging to the Worms. But, aside from such grounds, I was led, some time since, after considerable study of infusoria-forms, to venture an opinion quite at variance with that just mentioned of Siebold and Kolliker. I then made the following statement: In regard to the question, What characteristic in organic animal matter shall constitute an individual? I feel satisfied of this much,—that cell processes, however closely interwoven they may be with the expressions of individual life, cannot be considered as constituting the ground-work of its definition.§ This statement was made more than two years since; and subsequent observations, some of them of a special character, have not led me to a change of opinion. True individual animal life seems to involve a cycle of relations not implied in simple cells; in other words, these last must always lose their character as such, in a definite form which belongs to the individual.

On this account I regard the Infusoria proper, or those which have been shown to be of an undoubted animal character, as in a completely transition state; and, although it may be well to arrange these forms systematically, for the sake of convenience, yet they cannot be considered as holding fixed zoological positions. Further research in this direction, and upon "Alternation of Generation," will, I think, widely clear up this obscure, yet most interesting field of study.

Editor.

I. p. 270. II. p. 110.
BOOK FIRST.

INFUSORIA AND RHIZOPODA.

CLASSIFICATION.

§ 3.

The Infusoria, using this word in a restricted sense, are far from being the highly-organized animals Ehrenberg has supposed. In the first place, on account of their more complicated structure, the Rotifera must be quite separated from them, as has already been done by Wiegmann, Burmeister, R. Wagner, Milne Edwards, Rymer Jones, and others. The same may be said of the so-called Polygastrica. In fact, a great number of the forms included under Closterina, Bacillaria, Volvocina, and others placed by Ehrenberg among the anenteric Polygastrica, belong, properly, to the vegetable kingdom. Indeed, this author has very arbitrarily taken for digestive, sexual, and nervous organs, the rigid vesicles, and the colored or colorless granular masses, which are met with in simple vegetable forms, but which are always absent in those low organisms of undoubtedly an animal nature. Cell-structure and free motion are the only two characteristics in common of the lowest animal and vegetable forms; and since Schwann (1) has shown the uniformity of development and structure of animals and plants, it will not appear strange that the lowest conditions of each should resemble each other in their simple-cell nature. As to motion, the voluntary movements of Infusoria should be distinguished from those which are involuntary, of simple vegetable forms; a distinction not insisted upon until lately. Thus, in watching carefully the motions of Vorticellina, Trachelina, Kolpodea, Oxytrichina, &c., one quickly perceives their voluntary character. The same is true of the power of contracting and expanding their bodies.

But in the motions of vegetable forms other conditions are perceived; and there is no appearance of volition in either change of place or form, their locomotion being accomplished either by means of cilia, or other physical causes not yet well understood. Cilia, therefore, belong to vegetable as well as to animal forms, and in this connection it is not a little remarkable that in animals they should be under the control of volition. With vegetable forms these organs are met with either in the shape of ciliated epithelium, as upon the spores of Vaucheria, (2) or as long, waving filaments, as upon the earlier forms of many confervæ, (3) in which last can

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3 The same. Pl. X.
often be seen the so-called organization of Ehrenberg's Monadina and Volvocina. Until the fact that ciliated organs belong to both animals and vegetables was decided, the real place of many low organisms had to remain undetermined. However, notwithstanding their free motion from place to place by means of cilia, the vegetable nature of many organisms seemed clearly indicated by the rigid, non-contractile character of their forms. It is from a misapprehension of the true nature of these facts, that some modern naturalists have denied the existence of limits between the two kingdoms.

With Bacillareae and Diatomaceae, this question has another aspect. Many of these organisms have been taken for animals from their so-called voluntary movements, which truly entirely want the character of volition. In the movements of the rigid Diatomaceae, for instance, the whole plant has oscillatory motions like a magnetic needle, at the same time slightly changing its place forward and backward. When small floating particles come in contact with such an organism, they immediately assume the same motion. This may be well observed with the Oscillatoria. There are here, undoubtedly, no ciliary organs; in fact, they could not, if present, produce this kind of motion. According to Ehrenberg, the Navicula can protrude ciliary locomotive organs through openings of their carapace; but this has not been observed by other naturalists.

§ 4.

The Rhizopoda, whose internal structure is as yet imperfectly known, are closely allied to the Infusoria. Like these last, their bodies are cellular, containing nuclear corpuscles, but no system of distinct organs. These two classes of Protozoa differ, however, in their external form, and the structure of their locomotive organs. The body of the Infusoria, notwithstanding its contractility, has a definite form, and moves chiefly by means of vibratile organs. That of the Rhizopoda, on the other hand, although equally contractile, has no definite form; their movements also are not due to ciliated organs, but to a change of the form of the body by various prolongations and digitations.

§ 5.

Owing to the present incomplete details upon the organization of these animals, little can here be said about them; and therefore, instead of devoting to them a separate chapter, it will be proper to treat of them with the Infusoria in general.

As the division of the Polygastric Infusoria, by Ehrenberg, into two

4 As an example, may be mentioned the various and dissimilar opinions of naturalists upon the question of the animal or vegetable nature of the "red snow," a question upon which Flotow, after the most careful studies, is still undecided. See Flotow, "Über Haematococcus pluvialis," in Nov. Act. Acad. Leop. Curd., vol. XX. part ii. p. 18.

6 See Unger, Die Pflanze im Momente der Theorverung. Wien. 1845.

Also, Kützing, Ueber die Verwandlung der Infusorien in niedere Algenformen. Nordhausen, 1844. In an academie paper (Dissertatio de finibus inter regnum animal et vegetable constituenides, Erlangen, 1844), I have attempted to show that this confusion between the two kingdoms does not exist.

6 Abhandlungen der Akademie der Wissenschaften zu Berlin, 1836, p. 134, Taf. I. fig. 19, and 1839, p. 162, Taf. IV. fig. 5.
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INFUSORIA AND RHIZOPODA. § 5.

orders, Acintidera and Enterodela, appears unfounded, the following classification seems more natural:

PROTOZOA.

CLASS INFUSORIA.
Organs of locomotion chiefly vibratile.

ORDER I. ASTOMA.
Without an oral aperture.

FAMILY: Astasiaea.
Genera: Amblyophis, Euglena, Chlorogonium.

FAMILY: Peridiniae.
Genera: Peridinium, Gloeodinium.

FAMILY: Opalinaea.
Genus: Opalina.

ORDER II. STOMATODA.
With a distinct oral aperture and oesophagus.

FAMILY: Vorticellina.
Genera: Stentor, Trichodina, Vorticella, Epistylis, Carchesium.

FAMILY: Ophrydinia.
Genera: Vaginicola, Cothurnia.

FAMILY: Enchelia.
Genera: Actinophryis, Leucophryis, Prorodon.

FAMILY: Trachelina.
Genera: Glaucoma, Spirostomum, Trachelius, Loxodes, Chilodon, Phialina, Bursaria, Nassula.

FAMILY: Kolpodea.
Genera: Kolpoda, Paramaecium, Amphileptus.

FAMILY: Oxytrichina.
Genera: Oxytricha, Stylonychia, Urostyla.

FAMILY: Euplota.
Genera: Euplotes, Himantophorus, Chlamidodon.
$§$ 5. INFUSORIA AND RHIZOPODA.

CLASS RHIZOPODA.

Organs of locomotion consisting of completely retractile, ramifying prolongations of the body.

ORDER I. MONOSOMATIA.

Family: Amoebaea.
Genus: Amoeba.

Family: Arcellina.
Genera: Arcella, Diffugia, Gromia, Miliola, Euglypha, Trinema.

ORDER II. POLYSOMATIA.

Genera: Vorticialis, Geoponus, Nonionina.

BIBLIOGRAPHY.


Andrew Pritchard. A History of Infusoria, living and fossil, arranged according to the "Infusionsthierchen," of Ehrenberg. Illustrated by nearly 800 colored engravings of these curious creatures, highly magnified. London, 1841.


ADDITIONAL BIBLIOGRAPHY.

Besides the various articles quoted in the additional notes I have made, the following are among the more important recent writings on this subject:

Cohn. Beiträge zur Entwicklungsgeschichte der Infusorien, in Siebold & Köllicher's Zeitsch. III. Hft. 3, and IV. Hft. 3.


See also numerous notes in the Annales des Sciences Naturelles, since 1847. — Ed.

1 In this table are mentioned the families and genera of those only which have been the objects of anatomical study.
CHAPTER I.

EXTERNAL COVERING.

§ 6.

The Protozoa are surrounded by a very delicate cutaneous envelope, which is sometimes smooth, and sometimes covered with thickly-set cilia. Generally these cilia are arranged in longitudinal rows; but in Actino- phrys they consist of long contractile filaments of a special nature.

CHAPTER II.

MUSCULAR SYSTEM AND LOCOMOTIVE ORGANS.

§ 7.

With the Protozoa a distinct muscular tissue cannot be made out, but the gelatinous substance of their body is throughout contractile. It is only in the contractile peduncle of certain Vorticellina, that there can be perceived a distinct longitudinal muscle, which, assuming a spiral form, can contract suddenly like a spring.

§ 8.

The Vibratile Organs on the surface of Infusoria serve as organs of locomotion. With many species they are found much developed at certain points, and are arranged in a remarkable order and manner.

With Peridinium, a crown of them encircles the body; with Stylonychia, they are quite long, and surround the flattened body like a fringe; while the Vorticellina have the anterior portion of their body surrounded by retractile cilia, arranged in a circular or spiral manner. In Trichodina there is, upon the ventral surface, besides a crown of these cilia upon the back, a very delicate ciliated membranous border, which is attached to a ring which is dentated, and composed of a compact homogeneous tissue. With Trichodina pediculus this border is whole and entire; but it is broken or ragged with Trichodina mitra.

By means of this organ these animals swim with facility, or invade with skill the arm-polyps and Planaria. With many Infusoria, the vibratile organs are situated at the anterior extremity of the body, as simple or double non-retractile filaments, which move in a manner to produce a vor-

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1 Euglena, Amoeba, &c.
2 Trachelius, Paramécium, Nassula, &c.
3 Amphiploca, Chilodon, Opalina, &c.
4 The peduncle is simple with Vorticella, but ramified with Carchesium. With Epistyline it is not muscular.

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1 This Infusorium was discovered by me as a parasite in many Planariae.
2 Ehrenberg has entirely overlooked the ciliated border of Trichodina pediculus, and has regarded the stiff serrations of the ring as movable hooks. See "Die Infusionsthiere," p. 206.
tical action of the water.\(^6\) But with others the locomotive organ is a long retractile proboscis.\(^4\) With the Oxytrichina and Euplota, there are fleshy movable points (uncini) upon the ventral surface, by which these animals move about as upon feet. During these movements with the Oxytrichina, the posterior portion of the body is supported by many setose and styloid processes, which point backward.

The singularly varied and branching locomotive organs of the Rhizopoda are short, and digitated with Amoeba, Diffugia and Arcella.\(^5\) But in the other genera they are elongated and filamentous.\(^6\)

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**CHAPTERS III. AND IV.**

**NERVOUS SYSTEM AND ORGANS OF SENSE.**

**§ 9.**

Although the Infusoria clearly evince in their actions the existence of sensation and volition, and appear susceptible of sensitive impressions, yet no nervous tissue whatever has as yet been found in them. If Ehrenberg supposed the Polygastric Infusoria to possess a nervous system, he did so because, having decided that the red pigment points of these animals were eyes, he inferred that they necessarily had a nervous ganglion at their base.

**§ 10.**

With the naked Infusoria the sense of touch exists, undoubtedly, over the whole body. But beside this, it appears specially developed, in many species, in the long cilia forming vibratile circles, or in those movable foot-like and snout-like prolongations of the body. In the same manner, it is probable they have the sense of taste also; for they seem to exercise a choice in their food, although no gustatory organ has yet been found.

All species, whether they have red pigment points or not, seem affected by light. Without doubt, therefore, their vision consists simply in discriminating light from darkness, which is accomplished by the general surface of the body, and without the aid of a special optical organ.

The simple pigment point of many Infusoria,\(^1\) and which Ehrenberg has generally regarded as an eye,\(^2\) has no cornea, and contains no body capable of refracting light; there is, moreover, connected with it no nervous substance.

Ehrenberg attaches here too great an importance to the red color of the

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\(^3\) Amblyphis, Euglena and Peridinium, have a simple flagelliform cillum, but with Chlorogonium it is double.

\(^4\) Trachelius trichophorus feels about with a long snout of this kind, without, however, producing a vertical motion on the water.

\(^5\) See Ehrenberg, "Die Infusionstürkchen."

\(^6\) Taf. VIII. and IX.

\(^1\) Crassia fluviatilis, Milia vulgaris, Verticilis striatilis, Euglypha tuberculosa, Trinema acinus, according to Dujardin (Ann. des Sc. Nat. Zool. IV. 1835, p. 343, pl. IX.; also, V. 1836, p. 106, pl. IX. fig. A. See, also, his Histoire des Infusories, 1841, p. 249, pl. L. fig. 14-17; pl. II fig. 1, 2, 7-10; pl. IV. fig. I); Geoporus stelato borealis, Nonionina germanica, according to Ehrenberg, Abhandl. d. Berliner Akad. 1839, p. 166, Taf. I. H.

\(^2\) Amblyphis, Euglena, Chlorococum, &c.

pigment, for the blue, violet and green pigments, seen in the eyes of insects and crustacea, show clearly that the red pigment is not essential to the eye.*

CHAPTER V.

DIGESTIVE APPARATUS.

§ 11.

The Infusoria are nourished, either by taking solid food into the interior of their body, or by absorbing by its entire surface nutritive fluids which occur in the media in which they live.

This last mode is illustrated in the Astomata, which have no distinct oral aperture or digestive apparatus. By the ingenious experiment first performed by Gleichen, (1) of feeding these animals with colored liquids, no trace of these organs could be found.

Ehrenberg, who also had observed that they did not eat, regarded their internal vesicles as stomachal organs, which were in connection with the mouth by tubes. The correctness of this opinion, however, has not been verified. Indeed, the genus Opalina (2) refutes it; here the species are quite large and visible to the naked eye, yet an oral aperture can be detected upon no part of their body, and never do they admit into its interior colored particles. Solid substances found in them cannot be regarded as food. That fluids are here introduced by surface-imbibition is shown by Opalina ranarum; this animal is found in bile in the rectum of frogs, and assumes a green color. When Opalina requiring only a certain quantity of liquid are placed in water, they quickly absorb it, become greatly swollen, and shortly after die. In such cases, the absorbed liquid is seen as clear, vesicular globules under the surface, and these globules have been taken by Ehrenberg as stomachal vesicles (ventriculi), and by Dujardin as vacuolae.

§ 12.

Those Infusoria which are nourished by solid food have a mouth at a certain place, and an oesophagus traversing the parenchyma of the body. Through this last the food is received, and is finally dissolved in the semi-liquid parenchyma of the body, without passing through stomachal or intestinal cavities. In many cases there is at the end of the body opposite the mouth an anus, through which the refuse material is expelled. But, when this is

3 "Die Infusioschleiere," p. 492.
5 "Die Infusioschleiere," p. 492.
wanting, its function is often performed by the mouth. According to Ehrengberg, the Infusoria polygastrica, such as we have just been describing, differ from the Infusoria rotatoria, in having a great number of stomachs, which connect by hollow peduncles with the mouth in the division Anentera, and with the intestine in that of Enterodela. This organization, which, from its high authority, has generally been admitted by naturalists, is not, however, met with in any infusorium.\(^1\)

The vesicular cavities in the bodies of these animals, and which have been regarded by Ehrengberg as stomachal-pouches, never have a hollow peduncle, either connecting with the mouth (Anentera) or with the intestine (Enterodela). Indeed, it is doubtful if a digestive canal can be made out in these Infusoria.

The vesicular, irregular contracting cavities of their body contain a clear liquid, evidently the same as that in which they live, which, with the Astoma, has been absorbed through the surface of the body. But, with those having a mouth and oesophagus, it is received through them, and taken up by the yielding parenchyma of the body.

If the methods of feeding of Gleichen and Ehrengberg are employed, the colored particles are taken in by a vortical action of the water, caused by the cilia surrounding the mouth. This water, with its molecules, accumulates at the lower portion of the oesophagus, and so distends there the parenchyma as to cause the appearance of a vesicle. Thus situated, the whole has much the aspect of a pedunculated vesicle. But when, from contractions of the oesophagus, this water escapes into the parenchyma, it appears there as an unpedunculated globule, in which the colored particles still float. When the Stomatoda are full-fed in this manner, there appear many of these globules in various parts of the body; and thus substances previously ingested are taken up and disseminated throughout the body.

If the globules thus containing solid particles are closely aggregated, it sometimes happens that they fuse together; a fact which proves that they are not surrounded by a special membrane.

The solid particles of the Stomatoda, which are often the lower Algae, such as the Diatomaceae and Oscillatoria, and often other Infusoria, are sometimes deposited in the parenchyma without being surrounded by a vesicular liquid.\(^2\)

From observations made upon Annaba, Arcella and Diffugia, it appears that the Rhizopoda ingest their food like the Stomatode Infusoria.

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\(^1\) Focke (Isis, 1836, p. 785) has already raised doubts as to the existence in Infusoria of the stomachs described by Ehrengberg. Ehrengberg has also opponents in Dujardin (Ann. des Sc. Nat. Zool. iv. 1835, p. 364; V. 1836, p. 193; X. 1838, p. 239; also Hist. Nat. des Infus. 1841, p. 57.), in Meyen (Muller's Arch. 1839, p. 74) and in Rymner Jones (Ann. of Nat. Hist. iii. 1839, p. 106; also, "A General Outline of the Animal Kingdom," 1841, p. 59). He has attempted to reply to the objections here urged by very detailed illustrations of the organization of the Polygastrica, made by him and Fer-

\(^2\) Bailey (Amer. Jour. Sc. May, 1853, p. 351) has recently published an account, accompanied with numerous figures, of a new animalcule, which is so remarkable in this connection that I give here his description. He says: "If the reader will imagine a bag made of some soft extensible material, so thin as to be transparent like glass, so soft as to yield readily to extension when subjected to internal pressure, and so small as to be microscopic in this bag, filled with particles of sand, shells of
§ 13.

If the vesicular cavities containing the liquid and colorless food of the Stomatoda be examined under the microscope by a horizontal central incision, their contents appear colorless; but by changing the focus, viewing alternately the convex and concave surfaces of the vesicle, the points of junction between the colorless globules and the parenchyma appear colored pale-red. This appearance, due to an optical illusion, might easily deceive one into the opinion that the vesicles which are really colorless are colored.

From this it is probable that Ehrenberg has described Bursaria vernalis and Trachelius melagris as having a red gastric juice.\(^1\)

The violet points which are found upon the back and neck of Nassula elegans and Chilodon ornatus are only collections of pigment granules, which, in the first case, are often absent, and in the second are often partially dissolved.

This last violet liquid has been regarded by Ehrenberg\(^2\) as a gastric juice resembling bile.

§ 14.

The solid particles of food, whether surrounded by the parenchyma or enclosed in a liquid vesicle, are moved hither and thither in the gelatinous tissue of the body, during the contracting and expanding movements of the animal. In some, the parenchyma with its contained food moves in a regularly circular manner, like the liquid contained in the articulated tubes of Chara.\(^3\) In Loxodes bursaria\(^4\) this circulation is remarkable, and of much physiological interest. Its cause is yet quite unknown, for in no case is it due to cilia, and it may be observed in individuals entirely at rest. Ehrenberg,\(^5\) therefore, is incorrect in regarding it as due solely to a contractile power of the parenchyma, displacing the molecules. Much less is his explanation\(^6\) satisfactory, since the digestive tube of an infusorium can be extended at the expense of its stomachal pouches, so as to fill the whole body, giving it the appearance of having a circulation of molecules throughout its entire extent.

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3. Vaginula and Vorticella. See Focke, Arch. Diatomacea, portions of Algae or Dermidicae, and with fragments of variously colored cotton, woolen, and linen fibers, will give a picture of the animal; to complete which, it is only necessary to add a few loose strings to the bag to represent the variable radiating processes which it possesses around the mouth. This animal, which is often found with bits of cotton protruding from its mouth, assumes the most bizarre shapes. They appear to multiply by fissionation and gemmation even when filled with these heterogeneous particles, and, on the whole, present characteristics as remarkable, as those of any animalcule with which we are acquainted. — En.
4. [§ 13, note 2.] In this connection should be noticed the experiments of Will (Müller's Arch. 1848, p. 509). He found evidences of a bilary apparatus, with Vorticella, Epiplagia, and Bursaria. These evidences are based on chemical solution, and he describes no anatomical apparatus. I mention this fact here, although Vorticella belongs truly to the Bryozoa, and Bursaria to the Phana-
§§ 15, 16.

INFUSORIA AND RHIZOPODA.

§ 15.

The round or elongated oval mouth of Infusoria varies as to its position. Sometimes it is in front, sometimes behind; and in some cases, near the middle third of the body. Rarely naked, its borders are generally ciliated, and often its circumference is provided with a very remarkable ciliary apparatus. By the aid of this, these animals not only move about, but when quiet produce vortical actions of the water, which are felt at quite a distance; and all minute particles within its reach are quickly drawn towards its mouth, and then swallowed or rejected according to the option of the individual.

It is rare that this oral aperture is provided with a dental apparatus. The oral cavity, generally infundibuliform, extends into a longer or shorter, straight or curved oesophagus, which is lined throughout by a very delicate ciliated epithelium.

The anus, situated usually upon the dorsal surface of the posterior portion of the body, is sometimes, though rarely, indicated by a slight external projection.

CHAPTERS VI. AND VII.

CIRCULATORY AND RESPIRATORY SYSTEMS.

§ 16.

A vascular system entirely distinct by closed walls from the other organs is not found in the Protozoa. But with very many (with all the Stomatoda, without exception) there are contractile pulsatory cavities, the form, number and arrangement of which is quite varied.

They are situated in the denser and outer layers of the parenchyma of the body, and during the diastole they become swollen by a clear, transparent, colorless liquid, which, during the systole, entirely disappears.

1 *Actinophrys.* The mouth is naked also in the genera *Difflugia* and *Arcella* of the Rhizopoda.

2 *Bursaria,* Paramaecium, *Urostyla* and *Stylonychia.* In *Gleneaena scalpellum* the ciliated crown of the mouth is replaced by a special semilunar ciliated labes.

3 In *Stentor,* *Vorticella,* *Epistylis* and *Trichodina,* this apparatus is retracile, and produces in a particular way the vertical actions. In *Spinostoma ambiguum,* there is a long, narrow, ciliated furrow, through which the food is conducted to the mouth, situated at the posterior portion of the body.

4 *Prorodon,* *Nassula,* *Chilodon* and *Chilamidodon.* Here the hair-like teeth are arranged in a cylinder so as to resemble a weir.

5 The osophagus is short in *Ozytricha,* *Stylonychia,* and *Epistyles;* but is elongated or spiral in *Vorticella,* *Carchesium* and *Epistyles;*

while it is long and arcuate in *Bursaria truneata* and *cordiformis.*

6 The undigested matters accumulate about the anus, and when this opens are expelled from the parenchyma with a certain force. With *Nassula elegans,* the greater or less portions of the *Oscillatoria gracillima* (*Kutzing*) upon which it feeds, and which are of a blue-green color, dissolve into granules of this color. But these, during the process of digestion, gradually assume a brown color, and form irregular masses in the posterior portion of the body, and are from time to time expelled as brown feces. These green granules are not therefore eggs, as Ehrenberg (*loc. cit.* p. 339) has supposed. This *Nassula* when young is perfectly colorless, with the exception of a beautiful blue spot.

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[*§ 15, note 1*] Kölöker (*Siebold* and Kölöker's *Zeitsch.* L. 1849, p. 108) has given a long and detailed description of *Actinophrys sol.* According to him, it is without mouth or stomach proper, and internally is composed of a homogeneous substance. Yet this remarkable animal lives on other Infusoria, Algae, &c., and avails itself of them by seizing and afterwards invaginating them in its parenchyma, until they finally are included within its interior. — Ev.
These movements succeed each other at more or less regular intervals. When these cavities are numerous, a certain order in the succession and alternation of their contractions cannot always be observed. It is very probable that their liquid contained during the diastole is only the nutritive fluid of the parenchyma, and to which it returns during the systole. In this way it has a constant renewal, and all stagnation is prevented. This arrangement constitutes the first appearance of a circulatory system, and the first attempt at a circulation of nutritive fluids.

From an optical illusion similar to the one mentioned as belonging to the vacuole (§ 13) the liquid of these pulsating cavities has a reddish hue.\(^1\)

§ 17.

A round, pulsating cavity is found in the genera Vorticella, Epistylis, Loxodes, and in the following species: — Ameba diffinens, Paramecium holopoda, Stylyonchla mytilus, Euplotes patella, &c. With Actinophrys, Bursaria, Trichodina, there are from one to two; with Arcella vulgaris, three to four; with Nassula elegans, there are four placed in a longitudinal line on the dorsal surface. With Trachelius meleagris, there is a series of eight to twelve upon the sides of the body, and with the various species of Amphileptus there are fifteen to sixteen arranged more or less regularly. With Stentor, there is a large cavity in the anterior portion of the body, and many similar cavities appear upon the sides, united sometimes into one long caud. A similar caud traverses the entire body of Spirotonum ambiguum, and Opalina planaria. With Paramecium aurelia, the two round cavities present a remarkable aspect, being surrounded by five or seven others, small and pyriform, the top of which being directed outward, the whole has a star-like appearance.\(^0\) During the pulsation, often the entire star disappears, sometimes only the two central cavities, and in some cases the rays only.

These cavities, entirely disappearing in the systole, reappear in the diastole, and usually in the same place and with the same form and number. This would lead us to conclude that they are not simple excavations in parenchyma, but real vesicles or vessels, the walls of which are so excessively thin as to elude the highest microscopic power.

In some individuals, as, for instance, with Trachelius lamella, there appear, during the diastole, two or three small vesicles at the extremity of the body, which, after having increased in size, blend into one which is very large. These are probably only globules of nutritive fluid, separated from the parenchyma. Similar phenomena are observed in Phialina vermicularis and Bursaria cordiformis.

It sometimes happens with these animals that a forcible contraction of the whole body divides an elongated cavity into two spherical portions, as

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\(^1\) Ehrenberg (loc. cit. p. 321, Taf. XXXIII. fig. viii.), described by this illusion, has taken the eight to twelve contractile cavities of Trachelius meleagris for stomachal cells, filled with red gastric juice. He has also regarded these cavities, when simple or double, as seminal vesicles. (Abhandl. d. Berliner Akad. 1835, p. 372; — 1835 p. 385.) In species having but few, he has very arbitrarily decided that some are seminal vesicles, others stomachal pouches, as, for example, in Amphileptus (loc. cit. p. 550). According to him, the seminal vesicles, upon contraction, pour the sperm upon the eggs contained in the body. It really seems very strange that these animals should practise uninterrupted these pollutions throughout their entire life. These animals have neither testicles nor ovaries, and the function of these cavities is not, therefore, that assigned to them by Ehrenberg, — but is, as I think, with Wiegmann (Arch. f. Naturg. 1834, L p. 32), analogous to that of a heart.

\(^0\) Hufnagel, Ann. d. Sc. Nat. Zool. t. V. Pl. XV. fig. 3; also, "Infusoria," Pl. VIII. fig. 6. Ehrenberg's plates of these star-like vesicles are incorrect.
though it were a drop of oil. The observation of these phenomena would make it doubtful whether or not these cavities are true vesicles or vessels.

These cavities have been met with in only a few of the Astoma, and these are, Cryptomonas ovata (2) and Opalina planariarum.

§ 18.

The Infusoria appear to respire solely by the skin. In those species whose bodies are covered with vibratile cilia this function is promoted by the vortical action of the water caused by these organs. In others, the contractile cavities just described are situated immediately under the skin, and the opinion may be entertained that the water so communicates with their liquid contents as to perform a respiratory function. In this respect Actinophrys sol is quite remarkable, for its contractile cavities are so superficial that when filled they raise the skin in the form of aqueous vesicles, which, however, are so elastic as entirely to disappear in the parenchyma. Here it is plain that a mutual relation between the external water and the contents of these cavities might easily take place.

CHAPEL VIII.

ORGANS OF SECRETION.

§ 19.

No special organ of secretion has been found in the Protozoa; their skin, however, has a power of secreting various materials, which in some species harden and form a carapace, or a head of a particular shape; while in others it serves to glue together foreign particles, forming a case, in which the animal retreats.

Among those having a carapace, may be mentioned Vagmicola, Cothurnia, and Arcella. This more or less hard envelope does not resist fire, and is probably of a corneous nature. In the Rhizopoda, however, it is usually calcareous, like the shells of Mollusca, and is not affected by heat. The Difflugiae carry about with them an envelope of this kind, composed of grains of sand.

(2) Ehrenberg, loc. cit. p. 41, Taf. II. fig. xvii.

Ehrenberg (ibid. p. 306, Taf. XXXI. fig. vi. 1) appears to have taken the protrusion of these contractile vesicles for that of a snout.
CHAPTER IX.

ORGANS OF REPRODUCTION.

§ 20.

The Infusoria propagate by fissuration and gemmation, and never by eggs.\(^1\) They have therefore no proper sexual organs.

This fissuration occurs longitudinally with some,\(^2\) transversely with others,\(^3\) and in many of them by both at once.\(^4\) Gemmation, on the contrary, is very rare.\(^5\)

§ 21.

Nearly all the Infusoria and Rhizopoda have in their interior a nicely-defined body, a kind of a nucleus, which is quite different, in its compact texture, from the parenchyma by which it is surrounded. This nucleus, which, in different species, varies much in number and form, performs an essential part in the fissuration. For, every time the individual divides either longitudinally or transversely, this nucleus, which is usually situated in the middle, divides also. So that, in the end, each of the two new individuals has a nucleus. When an animal is about to undergo fissuration, there is generally first perceived a change in the nucleus. Thus, in Paramacium, Bursaria and Chilodon, the nucleus is sulcated longitudinally or transversely, or even entirely divided,\(^6\) before the surface of the body presents any constriction.

This nucleus, which is of a finely granular aspect and dense structure, retains perfectly its form when the animal is pressed between two plates of glass, and the other parts are spread out in various ways. By direct light its color appears pale yellow. It appears to lie very loosely in the parenchyma, and sometimes individuals may be observed turning their bodies around it as it rests motionless in the centre. From all this, it cannot be supposed that this nucleus attaches itself to other parts of the animal, and especially to the pulsatory cavities (Vesicula seminates of Ehrenberg).\(^7\)

§ 22.

A simple, round, or oval nucleus is found in Euglena, Actinophrys, Arcella, Amoeba, Bursaria, Paramacium, Glacoma, Nassula and Chilodon. But there are two which are round, and placed one after the other in Amphiileptus anser and fasciola, in Trachelius melagris, and Ozyriacha pellionella. With Stylonychia mytilus, there are four.

1 That which Ehrenberg has arbitrarily taken for eggs is sometimes granules of the parenchyma or pigment corpuscles, sometimes bits of food. He did not perceive that these bodies want all that which is necessary to make up an egg,—such as chorion, vitellus, and germinative vesicle and dot. It is on this account that he declares that he never has observed the hatching of young Infusoria. (Abhandl. d. Berliner Akad. 1835, p. 165.)

2 Forticella, Carchesium.

3 This may be easily observed with Stentor, Leucophrys, Loxodes, and Bursaria.

4 Bursaria, Ophysa, Glacoma, Chilodon, Paramacium, Stylonychia and Euplopes.

5 Forticella, Carchesium and Epistylius.

6 Ehrenberg, loc. cit. Taf. XXXVI. fig. viii. 13 to 19, Taf. XXXIX. fig. ix. 4, 5, 11–13.

7 Ehrenberg, from a strange fancy, has taken this nucleus for a seminal gland. (Abhandl. d. Berliner Akad. 1835, p. 165. Also, loc. cit.)
§ 23. INFUSORIA AND RHIZOPoda.

It is not rare that a variable number of these round nuclei, arranged in a row, traverse the body in a tortuous manner. This is so in *Stentor coeruleus* and *polymorphus*, in *Spirostomum ambiguum*, and in *Trachelius moniliger*. In many instances the nucleus has the form of an elongated band, which is slightly curved in *Vorticella convallaria*, *Epistyliis leuca*, *Prorodon niveus* and *Bursaria truncatella*. In *Stentor Rasselii*, it is spiral, and in *Euplotes patella* and *Trichodina mitra*, it is shaped like a horse-shoe. In *Loxodes bursaria*, it is kidney-form, and encloses in one of its extremities a small corpuscle (nucleolus).

The round nucleus of *Euglena viridis* has in its centre a transparent dot. In *Chilodon cucullulus*, the nucleolus has a similar dot, and thus the nucleus as a whole resembles a cell.

§ 23.

These nuclei, which make Infusoria resemble cells, deserve a special attention, since they do not die with the animal. Thus the nucleus of *Euglena viridis*, which, according to Ehrenberg, is globular when dying, and surrounded by a kind of cyst, remains unchanged a long time, or even increases in size, having no appearance of a dead body. It may be that the life of this animal, under these circumstances, is not finished, but only assumes another form.\(^1\)

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2 Perhaps this nucleus, of which the animal is only a temporary envelope, is ultimately developed into a particular animal. Indeed, perhaps this species, as well as many others, are only the larval states of other animals, whose metamorphoses are yet unknown. It may properly be asked, if this nucleus has not, relative to the body containing it, the same signification as have the tubulous larve of *Monostomum mutabile* (see below) to the embryos they surround.

That the nucleus contained in Infusoria plays an important part in the propagation of those animals, is supported also by a recent observation of Focke, who witnessed the development of several young individuals in the nucleus of *Loxodes bursaria*. See Amtl. Bericht über die 22 tr. Versamml. deutsch. Naturforscher. in Bremen, Abth. ii. p. 110.
INTRODUCTORY NOTE TO THE ZOOPHYTA.

Within the past six or seven years the Zoophytes have received more attention from naturalists than any other division of the animal kingdom. The labors of many, if not most of our ablest naturalists, have been directed towards an investigation of the humblest forms of animal life. This fact, combined with the recent improved methods and means for research, would alone be prophetic of the most signal advances in this group; indeed, our knowledge of all these forms has been so modified, as well as increased, that previous writings need rather to be re-written than revised. Dana, Agassiz, Milne Edwards, Forbes, Dalvett, Müller, Busch, and others, not to mention the continued labors of older observers, have effected these changes in this group.

The work of Dana is most excellent, and will remain a standard of authority in this department for a long time to come. Aside from the many details of structure, in it may be found the first and best philosophical exposition of the relations of organic development with these lower plant-like forms. Had this work been better known in Europe, there would have been saved the constant repetition of the most grave errors. On the labors of Agassiz no comment need be made; those who are in this department, whether as minute Anatomists or philosophical Zoologists, will not fail to understand and appreciate him. In the same field is Busch, who was extended his brief though excellent labors over the three classes of this whole group; as for the remaining authors mentioned, excepting Müller, their position in this department has long been established. Müller's researches have been mostly on the Echinoderms, and the careful tracing of the phases of their development and metamorphoses; but where so much has been done, I fear the limits of this book will preclude full details with this class.

This note would be unnecessary, were it not to show that I do not ignore the changes and advance which have been made in this group within the past few years; and more especially so, as I have allowed, in this edition, the classification to stand as in the original. Any great changes of this
kind I could not think of making without the consent of the authors, who, although they would undoubtedly fully sanction them, are not sufficiently accessible to me just now, as these pages are going to press. So, however much the present classification may offend the eye of the Zoologist, yet the Anatomist will find under each head the proper details. Thus, he will find as full a description of the anatomical structures of the Bryozoa and Hydroid Polypi, as though they were referred to the Mollusca and Acalcephae, where truly they respectively belong.
BOOK SECOND.

POLYPI.

CLASSIFICATION.

§ 24.

The Polypi are either immovably fixed, or seated on a locomotive foot. Their soft body is in part enveloped by a solid support, the polypary. This last is often, for the most part, horned or calcareous; and by it numbers of these animals are united into greater or less groups. The central mouth is always surrounded by a corona of contractile tentacles. The digestive apparatus is organized after two different types, upon which is based a division of these animals into two orders. The sexual apparatus is always without copulatory organs.

ORDER I. ANTHOZOA.

The digestive canal is without an anus, and opens into the general cavity of the body.

Family: Madreporina.
Genera: Oculina, Millepora, Madrepora, Caryophyllia, Astraea, Desmophyllum, Maeandrina, Monticularia, Agaricia, Favia.

Family: Gorgonina.
Genus: Gorgonia.

Family: Isidea.
Genera: Corallium, Isis.

Family: Tubiporina.
Genus: Tubipora.

Family: Alcyonina.
Genera: Alcyonium, Lobularia, Alcyonidium.

Family: Pennatulina.
Genera: Veretillum, Pennatula, Virgularia.
§ 24. THE POLYPI.

**Family:** Sertularina.
**Genera:** Sertularia, Campanularia.

**Family:** Zoanthina.
**Genus:** Zoanthus.

**Family:** Hydrina.
**Genera:** Hydra, Eleutheria, Synhydro, Coryne, Syncoryne, Corymopha.

**Family:** Actinina.
**Genera:** Actinia, Eumenides, Edwardsia.

**ORDER II. BRYOZOA.**

The digestive canal is closed from the general cavity of the body, and opens behind through an anus.

**Family:** Reteporina.
**Genera:** Eschara, Cellepura, Flustra, Bicellaria, Retepora, Telegraphina, Tendra.

**Family:** Alcyonellina.
**Genera:** Cristatella, Alcyonella, Bowerbankia, Vesicularia, Lagenella, Plumatella, Lophopus.

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**BIBLIOGRAPHY.**


Besides the important work of Dana, which will be often quoted in my notes, the additions to the literature of the true polyps have been few since the issue of this work, and have generally been published in the form of articles in the various periodicals, to which reference will be made in my notes. But the Bryozoa have been specially studied, and particularly in the following papers:

1. There are here enumerated only those families whose organization has been specially studied. This remark applies equally to the following classes.


For further literature on the Bryozoa, see the writings quoted in my notes, and especially those of Allman.

CHAPTER I.

CUTANEOUS ENVELOPE AND SKELETON.

§ 25.

The Polypi are composed of either entirely soft parts, (1) or have for their support a solid frame, which may be calcareous, corneous, or coriaceous. This frame is always the product of the general skin, and ought therefore to be compared to a cutaneous skeleton. (2) This skeleton, known by the name of polyary, is formed partly internally, and partly externally, by these animals. In the first case it is called an axial, and in the second a tubular polyary.

The axial polyary consists, with some polyps, (3) of a dense substance, apparently unorganized and composed of carbonate of lime; with others, (4) of a corneous substance, equally unorganized. When the polyary is coriaceous, it is often covered by a variable number of calcareous, fusiform corpuscles, usually bossed or dentated. (5) With some calcareous polyaries (6) this is also true, and then the corpuscles are arranged in compact reticulated masses. The tubular polyaries serve as a refuge for the animals living in them, and in many cases, being common to many individuals, these last are in direct relation to each other by the canals which traverse the branching tubes. In the axial polyaries there are often cavities or depressions of a variable size, (7) in which the animals can conceal themselves. When, however, these are wanting, (8) they retire, as is the case with many soft polyps, (9) beneath their mantle. Sometimes, (10) these cavities are closed by a movable operculum.

§ 26.

The skin of polyps is very transparent, and should be carefully distinguished from the parenchyma which it envelopes. It is smooth, or it is covered with ciliated epithelium. And, since it has been shown that many

1 The Actinina and Hydrina.
2 Coralium.
3 The Gorgonina.
4 These corpuscles are easily seen in Alcyonia and Lobularia. (Milne Edwards, Ann. d. Sci. Nat., Zool. IV. 1855, pl. XIII. fig. 9; Pl. XV. fig. 10—11.) Spicula of this kind are found in the interior of their tissues, as well as on the surface. Ehrenberg (Abhand. d. Berl. Akad. 1841, Th. I. p. 403, Taf. I—III.) has described and figured these spicula under the names of Spongolithis and Lithostylidium.
5 The Madrepora.
6 Millepora, Madrepora, Oculina and Astraea.
7 Gorgonina, Isis and Coralium.
8 The Actiniae.
9 Eschara and Cellepora.

* It should here be remarked that the old, and as now regarded, mistaken view of the formation of the frame of Polyps is here repeated; for the frame is generally an internal skeleton, as, for instance, with Madrepora, Astraea, &c. For the formation of Coral, see Dana, loc. cit., and for the relations of the Corallium carried out in detail, see Edwards and Haime, Ann. d. Sci. Nat. 1849, 26, 51. — Ed.
Anthozoa have the skin, and especially the tentacles, covered with cilia of this nature, \(^{(1)}\) these last cannot be regarded as forming a differential characteristic between them and the Bryozoa, as has been done by Ehrenberg. \(^{(2)}\)

§ 27.

The skin of many polyps is quite remarkable in having netting or poisonous organs, to which it is only of late that the attention has been directed. They consist of transparent vesicles, having a dense membrane, of a round, oval, or cylindrical form, containing a clear liquid, and a very delicate filament of variable length, which is usually spirally coiled. By the least irritation of the skin, the filament is thrown out of the vesicle, of which it appears to be only a prolongation. These filaments adhere to objects coming in contact with the skin, and in this way the vesicles in question are separated from it. \(^{(1)}\) These organs are probably the cause of the netting sensation felt when certain polyps are handled.

§ 28.

Still more interesting are organs analogous to those just mentioned, and which belong to various species of *Hydra*. \(^{(1)}\) They are found not only on the arms, but also upon the skin of the body and foot. They consist of oval vesicles, having a very long and delicate filament, which is slightly swollen and viscous at its free extremity, while the opposite one is directly continuous with the conical neck of the vesicle. The neck of each vesicle is surrounded by three hooks curved backwards. These are always elevated when the skin of the animal is irritated, and especially that of the arms when they seize their prey. This last is then wound about by the free, viscous end of the filament, and the attached vesicle being torn from the body, the whole is often entangled in the arms of adjacent polyps. When this occurs, the vesicles hang by their hooks to the arms of the polyps; and it is this that has given Ehrenberg the opinion that the vesicles are detached by their round extremity, that these animals watch their prey with the hooks erected, and that the vesicles and filaments can return into the interior of the arms. \(^{(1)}\) But it is probable that they (the hooks) act more as poisonous than as prehensile organs; for if those from the arm of a *Hydra* seize upon a *Nais*, a *Daphnia*, or a larva of *Chironomus*, these last quickly die, even if they escape immediately after being taken.

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1 Erdt has seen very distinct ciliated epithelium in *Actinia* and *Veretillum*. (See Müller’s Arch. 1841, p. 425.)


These netting organs, which are much more common in the lower orders of the animal kingdom than was at first supposed, are yet quite imperfectly known. Wagner first discovered them in the *Actinia*, although he regarded them at first as the spermatogonic particles of these animals. (Wiegmann’s Arch. 1835. II. p. 218, Taf. 111, fig. 7, also 1841, L. p. 41; Icones Zoot. Tab. XXXIV, fig. 24.) These researches have been extended by Erdt, who has shown that they also exist with *Veretillum* and *Alcyonium*. (Müller’s Arch. 1841, p. 423, Taf. XV. fig. 3–6 and 8, 9.) In *Alcyonium*, Erdt has observed the filament take, on its departure from the vesicle, first a ribbons-like, and then a spiral aspect. In *Desmoplum stellaria* (Ehrenberg), I have seen these cylindrical organs having a long spiral filament. With Edwardsia, *Quatrefages* has found these organs upon the whole surface of the body, as well as upon the arms. (Ann. d. Sc. Nat., Zool. 1842, XVIII. p. 81, Pl. II. fig. 4–6.) For the netting organs of the *Tubulariae* and the *Actiniae*, see also Wagner in Müller’s Arch. 1847, p. 195, Taf. VIII.

1 These were first described by Ehrenberg. (Mittheil. a. d. Verhandl. d. Gesellschaft natur. Freunde zu Berlin 2 tes. Quartal, 1836, p. 25; also, Abhandl. d. Berl. Akad. 1835, p. 117; 1836, p. 153, Taf. 11.) They have been carefully studied by Erdt (Müller’s Arch. 1841, p. 429, Taf. XV. fig. 10–13).

2 Ehrenberg has figured, literally (Abhandl. d. Berl. Akad. 1836, p. 133, Taf. 11. fig. 1) an *Hydra* in the act of seizing its prey with extended hooks. In reality this animal is never thus seen.
§ 28.

These poisonous and prehensile organs are destroyed by use, which is also true of the netting organs. But this loss is probably repaired by their speedy reproduction. This last circumstance may explain the various descriptions given them by different authors, for, probably they have been observed at dissimilar stages of development.\(^3\)

\(^3\) *Erdl*, who has discovered a great number of these netting organs, saw, in some cases, the thread directly continuous with the neck of the vesicle; in others, these webs appeared furnished with spines directed backwards; exactly as Wagner had before described, and as Kölker had often ob-

* [§ 28, note 3.] These netting organs of the Polypi have recently been very successfully studied by Agassiz, who has enjoyed the most enviable advantages with the Polypi and Acalephae of the North American coast. He has changed the entire aspect of the subject, besides almost exhausting it for future research. His special studies were made on the coral polyp of our southern coast, the *Astrangia Danae*, Agass. The complexity of structure of these *lasso-cells*, as he has very appropriately termed them, is truly wonderful for such minute forms. As I have also studied these forms, I will use my own language, in the description of what *Prof. Agassiz* has seen. There are several varieties of these cells or capsules, depending upon the arrangement and structure of the *lasso*; sometimes this last is a simple coil, sometimes it is coiled about a staff which is erected from the base, but which is also a part of the projectile apparatus. In the first case, the *lasso* is much the longer and may be fifty or seventy-five times the length of the vesicle; while, in the second case, it rarely exceeds the length of this last by more than sixteen or twenty times. In all cases, the essential feature of these organs is the *lasso* or internal cell, which is of a most curious structure. In the first place, it is, in general terms, only an inverted portion of the vesicle or cell itself, an internal instead of an external cilium, coiled up in a regular manner. When thrown out, therefore, it is wholly inverted, and its projection consists of an instantaneous turning of the whole inside out. But the *lasso*, delicate as it is, has still more delicate structures on its surface. These consist of barbels arranged in regular spiral rows, which extend to the very extremity of the *lasso*. At this last point, they almost clude the highest and best microscopic powers. These barbels all point backwards when the *lasso* is extended, and serve, no doubt, as teeth, to prevent it from slipping on the objects over which it is thrown. But these most delicate structures, which in beauty transcendent that of all other tissues, can be better appreciated by figures than by the most minute description; see *Agassiz’s Memoir on Astrangia Danae* (forthcoming in the “Smithsonian Contributions to Knowledge”), Pl. VI. These observations, however, were made in 1848; see *Proceed. Amer. Assoc. Advancem.* Sc. 1848, p. 68.

From my own observations there would, indeed, be nothing to add on the special points studied by *Agassiz*; but a remark or two may be made as to the development of these forms. The *lasso-vesicle* is, originally, only an epithelial cell, of a spheroidal shape. It soon elongates, its contents become cloudy, after which, the cell is seen, very faintly marked, lying on the inner wall. It would seem probable, therefore, that its formation was somewhat similar to that of the spiral vessels in plants, although it is true that the *lasso-cells* and these spiral vessels are analogous only in form and position, and not in structure. The details of the formation are unknown. These *lasso-cells* are more widely distributed among the Radiata than hitherto supposed. *Agassiz* (as he has informed me by letter) has observed them on most of the Polypi and Acalephae, and even with some of the Mollusca, and although their general structure is the same, there are points of difference of even a zoological value.

*Editor.*
CHAPTER II.

MUSCULAR SYSTEM AND ORGANS OF LOCOMOTION.

§ 29.

The movements of Polyps are performed, partly by contractions of the sides of their body, in which are found no muscular fibres, and partly by a true muscular tissue. The fibres of this tissue have not regular transverse striae, although during their contractions there are sometimes, though rarely, seen irregular transverse bands.\(^1\)

§ 30.

In those Polyps having a true muscular system, this tissue is composed of interlaced fibres, forming a layer beneath the skin. A coarse net-work of this kind is seen in the arms of Hydra, although in the foot and rest of the body there is scarce anything comparable to muscular fibres.\(^2\) Under the skin of Syn hydra\(^3\) and in the arms of Eleutheria\(^4\) this muscular system is much more apparent. A similar layer, very distinct, is observed in Actiniae, which, in their mantle, is composed of both longitudinal and circular fibres, the contraction of which draws the tentacles together, and this, combined with that of the radiating fibres of the foot, gives rise to the various forms of these animals.\(^5\)

The Bryozoa have the muscular system more apparent; in the cavity of their body completely isolated fasciculi are seen, composed of parallel fibres, serving especially for the withdrawal of these animals into their cells. These fasciculi arise from the internal surface of the body, and are inserted partly into the base of the tentacles, and partly into the neck and digestive canal,— thus serving almost exclusively as retractor of these last.\(^6\)

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1 Milne Edwards, who declares he has seen striated muscular fibres in Esehara (Ann. d. Sc. Nat. VI. 1836, p. 5), must have been deceived. I have been unable to perceive them in Esehara, Aicyonella, Cristatella, and other species. Nordmann also has not found them in Cellaria. (Observ. sur la Faune Pontique, 1840, p. 679 ; also Muller's Arch. 1842, p. cxxvii.) The irregular bands appearing during contraction, but afterwards disappearing, have been observed by Quatrefages with Edwardsia (Ann. d. Sc. Nat. XVIII. 1842, p. 84, pl. II. fig. 7, a-b).\(^7\)


3 Quatrefages, Ibid. XVIII. 1842, p. 231, pl. VIII. fig. 3.

4 Berthold, Beitr. zur Anat. u. Physiol. 1831, p. 16 ; also in the body of Edwardsia, Quatrefages has found longitudinal and circular fibres (Ann. d. Sc. Nat. XVIII. p. 84).

5 Similar muscles have been observed by Farre (Phil. Trans. 1837, p. 387) in Rowerbankia, Fistularia, Lavenella and other Bryozoa. Milne Edwards has seen them in Tubulipora and Esechera. (Ann. d. Sc. Nat. VIII. 1837, p. 324 ; VI. 1836, p. 23, pl. I. fig. 1, c, 1, d ; pl. II. fig. 1, a.) Coste has given a very detailed description of the

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* [§ 29, note 1.] Busk has described and figured the striated form of this tissue with Anguinaria spatulata and Notamia bursaria. (Trans. Microsc. Soc. of London, II.) I have been unable, however, after considerable search upon many Bryozoa, among which were several Aicyonella, to detect any appearances of this kind ; and I would venture a pretty confident opinion that in the species examined no such form of muscle is present. Quite lately, however, the subject has been carefully examined by Aitman (Rep. Brit. Assoc. 1856, p. 315), and his descriptions are such as to leave no doubt upon the existence of the striated fibre with the species he has examined, among which are the Paludicella. — Ed.
With *Eschara* there are, moreover, two fasciculi in each cell, which move its operculum, and thus close the entrance of this cavity.\(^{6}\)

\[\text{§ 31.}\]

Locomotion is performed by the Polyps in various ways.

With the *Hydrae*, by their long-stretching arms; with *Actiniae*, by the contractions of the disc of their foot;\(^1\) while the *Edwardsiae*, having elongated bodies which are not attached by a foot, progress by vermiform movements.\(^2\) With *Cristatella mirabilis*, the whole colony moves itself along by the foot-like basis, like the *Actiniae*.\(^3\)

Some Polyps, at a certain period of their development, move freely in the water by discoid contractions of their body, like the pulmonate Acalephæ.\(^4\)

\[\text{§ 32.}\]

A very remarkable peculiarity is the presence, in certain Bryozoa, of organs shaped like a bird's head, and which swing to and fro at the base of their cells. In some species, these organs have the form of lobster's claws, being composed of both a fixed and a movable piece. This last is corneous, and moved by a muscle which arises from a cavity in the first. It is not yet known by what means either this beak is opened, or the whole organ moves to and fro.\(^1\)

Equally unknown is the function of these singular organs, the movements of which persist after the death of the animal, and of which, therefore, they are independent.\(^2\) They are perhaps organs of defence or prehension, and analogous to the *Pedicellariae* of the Echinoderms.

1 These organs were first described by *Ellis* (Reaumur, *Hist. Nat. des Coas*. 1756, p. 51, pl. XX, fig. A). *Nordmann* (Observ. sur la Faune Pontique, 1840, p. 679, pl. III. fig. 4) has described and figured them with much accuracy. In *Cellaria avicularia, Biscellaria ciliata* and *Plustra avicularia*, they are formed like lobster's claws.

2 In *Reptora cellusosa* they are pincer-like, and in *Telegraphina* they are articulated stings. See also Kohn in *Förtep's* Notiz, 1841, No. 530, p. 70.

3 For the organs having the form of a bird's head and a beak, and which are present in certain Bryozoa, see also *Van Beneden*, Recherches sur les Bryozaires, in the Nouv. Mém. de Bruxelles, XVIII. 1844, p. 13, pl. II. III., and *Reid* in the Ann. of Nat. Hist. XVI. 1845, p. 355, pl. XII.


With *Paludicella*, the muscular system is somewhat different; there are here five sets, — the 1st, 5th, 6th, and 7th of the preceding, and the parietal muscles. But with the 1st there is here only a single instead of a double fasciculus. — *Ed.*
CHAPTERS III. AND IV.

NERVOUS SYSTEM AND ORGANS OF SENSE.

§ 33.

As yet only a very rudimentary and imperfectly distinguished nervous system has been made out in the Polyps; this consists of round masses, which are regarded as composed of nervous matter (ganglia), situated in the parenchyma. A ganglion of this kind has been supposed to have been observed about the mouth.¹

§ 34.

Investigations upon their organs of sense have not been more successful. However, the sense of touch appears developed over the whole surface of the body, but specially so in the extremely irritable arms and tentacles. But, as yet, no tactile nerves have been found in these parts. In the same manner, light, to which these animals show a greater or less sensibility, is perceived rather by the general surface of the body than by special organs.

There are, however, in some species, at particular stages of development, during which they swim freely about, certain nicely-defined bodies situated upon the sides of the body, and which may be regarded as special organs of light and sound. This is the case with Syncoryne,² and Coryne³ has in their place four red organs which correspond exactly to those found on the border of the disc of the pulmograde Acalephæ, and which have been regarded as organs of sense.

The organ seen at the base of the six arms of Eleutheria dichotoma has quite the appearance of an eye; that is, there can be distinguished in

¹ A double oesophageal ganglion has been observed by Dumortier (Mém. sur l' Anat. et la Physiol. d. Polyps composés d'eau douce 1836, p. 41, pl. II. fig. 2) in Lophopus cristatus (Plumatella cristata of Lamarck); and by Coste (Comp. rend. XII. 1841, p. 724) in the Plumatella in general. Nordmann also has seen a similar ganglion under the mouth of Plumatella compausulata (Lamarck) (loc. cit. p. 70), and of Tendra zostericola (Ann. d. Sc. Nat. XI. 1838, p. 190). According to Van Beneden, a nervous ring surrounds the oesophagus of Ancyella (Ann. d. Sc. Nat. XIV. 1840, p. 222). Coste asserts the presence of a nervous system in Pennatula (Forrier's neue Notizen, 1842, No. 450, p. 154). That which Sisson pretends to have discovered in the foot of Actinina (Ann. d. Mus. d'Hist. Nat. 1843, p. 443, pl. XXXIII. fig. 4) has been properly rejected by most modern zoologists, as an illusion. See Berthold, loc. cit. p. 6.

² Lovén, Wiegmann's Arch. 1837, I. p. 325.

³ Steenstrup, Uber den Generationswechsel, p. 25.

* [§ 33, note 1] Altman has observed with Cristatella mucedo a small roundish body situated at the upper end of the pharynx, and which he regards as a nervous ganglion (Rep. Brit. Assoc. Advanc. of Sc. 1846, p. 83). This observation he subsequently confirmed, and has observed with Plumatella repens this ganglion (which he terms the great oesophageal ganglion) send off a large filament to each of the tentaculiferous lobes; also a smaller one passing off at each side to embrace the oesophagus, while a very short one was distributed in the substance of this last organ. And, finally, another set of filaments were distributed to the organs about the mouth. See Report of the same, for 1849, p. 72. According to a late Report, this observer appears to have been able to make out a distinct nervous system in all the fresh-water Bryozoa, except Paludicella. He has, however, been able to detect no certain organ of special sense. See report of the same for 1850, p. 319. — Ed.
it a cornea, a crystalline lens and a red pigment layer surrounding the whole.\(^3\)

Furthermore, there are upon the border of the disc of the campanulate *Campanularia*, colorless corpuscles, containing a calcareous nucleus, which is transparent as a crystal and soluble in acid.

These organs should probably be regarded as the most simple form of the auditory organs, for they have only a single vestibule with its single otolite.\(^6\)

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**CHAPTER V.**

**DIGESTIVE APPARATUS.**

§ 35.

The digestive apparatus of Polyps is formed after two different types. With the Anthozoa it consists of a mouth and a simple stomachal sac without an anus. But with the Bryozoa, there is a mouth and anus, and a digestive canal which may be divided into the sections of oesophagus, stomach, small intestine and rectum.

§ 36.

The mouth of Polyps is usually surrounded by a circle of long, very contractile tentacles or arms. These tentacles are tubular, and connect with the cavity of the body.\(^1\) They are simple,\(^2\) or pennate,\(^3\) and may be disposed around the mouth in a single\(^4\) or a multiple\(^5\) circle; they are also frequently covered with cilia.\(^6\)

Thus, the cylindrical tentacles of *Actinia* are entirely covered by ciliated epithelium. With the Bryozoa, on the contrary, the slightly-flattened ten-

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\(^3\) Quatrefages, Ann. d. Sc. Nat. XVIII. 1842, p. 296, pl. VIII. fig. 1, d, d, and fig. 6.

\(^4\) See Krohn (Müller's Arch. 1843, p. 176) and Kölliker (Prorup's neue Notizen, 1845, No. 534, p. 91). *Van Beneden* has perceived in the campanulate and free individuals of *Campanularia gelatinosa* and *geniculata*, not only eight marginal bodies, each containing a calcareous nucleus, but also four nervous ganglia about the base of the stomach (Mém. sur les Campanulaires de la côte d'Ostende, 1845, p. 24–27, pl. II. III.). I am yet undetermined about the question whether, as *Van Beneden* thinks, these bodies have sometimes the function of organs of vision, and sometimes that of organs of hearing. I am also in doubt as to the opinion of Hirschke (Lehrte von den Eingeweiden und Sinnesorganen, 1844, p. 830), who regards as otolites the calcareous bodies which have been observed in the peduncle of *Veretillum cynomoriurn*. Nordmann (Versuch, einer Monogr. des Torigpes, p. 88) has described as auditory organs the marginal bodies of the free-swimming *Campanulariae*.\(^1\)

\(^1\) This cavity which is in the arms of most Polyps does not open outwards at the extremity of these organs. I doubt, in fact, if the Actiniaria are an exception to this. It therefore appears singular that Rymer Jones (A General Outline of the Animal King. p. 41, fig. 10), and Lesson (Duperrey, Voyage autour du Monde. Zoophytes, p. 82, No. 1, fig. 1), expressly mention and distinctly figure these openers; the first with an Actinia, the second with an Euméniade. According to *Van Beneden* (loc. cit. p. 15) the tentacles of *Campanularia* are without these cavities. But this is contradicted by Lovén (Wiegmann's Arch. 1837, Bd. 1, p. 222). In Hydra the cavities open distinctly into the stomach, as is probably the case with many other Hydrina. Frey and Leuckart likewise doubt the constant presence of an orifice at the apex of the tentacles of the Actiniaria.*

\(^2\) *Actinia, Hydra, Flustra* and Campanularia.\(^3\) *Feretillum, Lobularia, Isis, Gorgonia,* and Zoanthus.\(^4\) *Hydra, Flustra, Zoanthus* and *Veretillum*.\(^5\) *Actinia* and Caryophyllia.\(^6\) *Feretillum, Flustra, Eschara, Cristatella* and *Tubulipora*.\(^7\)

tacles have only a single row of cilia, which move regularly and voluntarily, like the rotary organs of the Rotatoria.

By means of the currents produced by the cilia of their tentacles, many Polyps draw towards their mouth light particles of food; (6) others make use of their ciliated arms to seize larger portions. (9) This act is aided by the netting and various prehensile organs, which are more usually found upon those Polyp-arms having no cilia. (9) These organs are found upon the tentacles of Actinia, Edwardsia, Veretillum and Alcyonium, and without doubt serve for the seizing of the prey as well as its retention until death.

But these should not be confounded with special prehensile organs found on the tentacles of certain species. These consist of a small coriaceous capsule, from which the animal can project a kind of sting. (9) By means of these organs, the animal can attach itself like a bur to external objects, and not by suction, as is generally supposed.

The circular or oval mouth is always situated in the centre of the anterior extremity of the body; it is often surrounded by a lip formed of circular fibres. (21) In a few species, the mouth projects like a cone at the base of the tentacles. (42) With the Plumatellae (63) the mouth is topped by a tonguelet covered with rapidly moving cilia. Some of the Anthozoa, which capture animals of considerable size, can, in swallowing them, dilate their mouth to an astonishing width. (44)

DIGESTIVE CAVITY OF ANTHOZOA.

§ 37.

The simple stomach of Anthozoa, which is of a variable length, opens in general directly external by means of the mouth, (1) and with a few species, only, is there a muscular oesophagus. (2)

With some, the stomach blends with the walls of the body, (3) but usually it is more or less isolated. There remains, therefore, a cavity of the body of variable size, and which is directly continuous with the cavities of the arms. In those Polyps living in colonies, it is prolonged into canals traversing the corallum, and in this way the cavities of the bodies of all the...
Polyps are placed in direct intercommunication. It is not rare to find this general cavity divided into chambers by mesenteric membranes stretching longitudinally from it to the external surface of the stomach. 4

The base of the stomach of many, and perhaps all of the Anthozoa, is pierced by one or more valvular openings, which communicate with the cavity of the body. 5 These animals, by controlling at will these orifices, can allow to pass into the cavity of the body the proper materials, which are probably water and liquid chyle. 6 This digestive apparatus thus communicating with the cavity of the body, reminds one of the organization of the Infusoria. 7

The cavity of the stomach is lined by very delicate ciliated epithelium, which is continuous through the orifices upon every surface of the cavity of the body and arms, and even into the intercommunicating canals of the corallum.

The color of the walls of the stomach is quite varied, and is due to certain pigmented cells which very probably perform the function of a liver; for these animals are entirely wanting in any other glandular appendix of the alimentary canal, analogous to a liver. 8

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4 There are often eight of these longitudinal chambers, as in ~Feretilium, Alecyonidum and Alcyonidium~ see Icones zool. Tab. XXXIV. fig. 2; also Ann. d. Sc. Nat. IV, 1832, pl. XVI. fig. 3, and pl. XII. fig. 3, 4). In Alcyonidium there are seven more. With Edwardsia the eighth mesenteric division does not reach the sides of the body (~Quatrefages loc. cit. pl. I. fig. 2). 9

5 These orifices were long ago observed by the elder anatomists upon various Polyps. Afterwards their existence was incorrectly doubted by other naturalists; for lately they have been distinctly made out. Thus, in ~Feretilium eynomorum~ (Rapp, Nov. Act. physico-medica XIV. 1832, p. 660), in ~Alcyonidium and Alcyonidium~ (Milne Edwards, Ann. d. Sc. Nat. IV. p. 325, pl. XV. fig. 6), and in Edwardsia (Quatrefages Ann. d. Sc. Nat. XVIII. p. 91).

In Sertularia and Campanularia there are openings between the stomach and the tubulous cavities of the corallum (Lister, Phil. Trans. 1834, p. 371, and Van Beneden, Mem. sur les Campanulaires, loc. cit. p. 17). There must be direct communication of this kind with the Alcyonidium, since they regularly reject by their mouth nettle filaments, from the chambers of their body. With Hydra, the stomach communicates, by an orifice situated at its base, with the narrow tubulous cavity of its cylindrical foot. But at the extremity of this tube there is no oval opening, and the tube itself cannot be regarded as a rectum, for it receives neither faces, nor fragments of food, and is not affected by the frequent enormous dilatations of these animals from surfet. Corda therefore is incorrect in assigning an anus to these animals. (Nov. Act. physico-medica XVIII. p. 562, Tab. XIV. fig. 2. E.) He appears to have entirely neglected the foot of this animal, which, however, has been well figured by Ehrenberg (Abhanda d. Bert. Akad. 1836, p. 561, Tab. II. fig. 1); and since Rouxel (Insectskenel. 111. Tab. LXXVIII. and LXXIX. fig. 2, and LXXXVI. LXXXVIII. fig. 6) has perceived it in all unmutated arm-polyps. Sars (Forskn. littor. Norvag, p.

6 [§ 37, note 4.] With all the Actinaria the lamellae of the visceral cavity are the multiples of six; all the Alcyonaria have eight of these lamellae. See Dana loc. cit. p. 49. — Ed.

7 [§ 37, note 5.] With the Actinidea, recent researches have shown that the stomach communi-

21) has found with a ~Loceneria~ a stomach opening inferiorly, and communicating directly with the cavity of the body. This communication has been observed also by Fry and Leuckart (Belit. p. 3) with the ~Actiniae~ and several other Anthozoa.

8 Quatrefages (Ann. d. Sc. Nat. XVIII. p. 87, 91) has seen the stomach of Edwardsia entirely filled with Spirarris, and other solid food, without any of it passing into the cavity of the body.

7 With Infusoria, the lower end of the esophagus is free, so that the food passes directly from it into the parenchyma of the body, where it forms a cavity; but with the Anthozoa, there is a stomach, from which chyle alone can pass into the cavity of the body.

9 These cells are white in Edwardsia, yellow in Alcyonidium and Alcyonidium, and brown in ~Feretilium and Hydra~. In the last, the brown is distinctly due to irregular pigment granules of that color, floating in the clear liquid of the cells. Probably these cells, by bursting, empty their contents into the stomach; at least, I have been able to find no excretory duct, such as Corda has figured with the Hydra fusca (Nov. Act. Acad. physico-medica XVIII. p. 302, Tab. XV. fig. 15—17; or Ann. d. Sc. Nat. XVIII. p. 356, pl. XIX. fig. 13—17).

In Hydra viridula, these brown cells of the stomach can easily be distinguished from the layer of green pigment belonging to the parenchyma of the body. Moreover, if a transverse section of this animal is made, there appears a wide difference of organization between the internal and external surface of the stomach; the first has ciliated epithelium and hepatic cells, the second a bare skin with prehensile organs. This being so, how can these animals be evered like the finger of a glove, as some naturalists have affirmed, and yet live? for the two surfaces of the stomach, so different, could not replace each other, and then again the cavities of the arms would open directly outward. Indeed, it is not possible to return unmutated an evered Polyp, since the inextensible cavity of its foot cannot leave the body with impunity. The gastric

cates with the cavity of the body by a single orifice only, which may be closed by muscles. See Dana, loc. cit. p. 40, 44, pl. XXX. figs. 3, 1, b, c, d. It has been since verified by Cobbold, Ann. Nat. Hist. XI. 1835, p. 121, with figures. — Ed.
**§§ 38, 39. THE POLYPI.**

### DIGESTIVE CAVITY OF BRYOZOA.

§ 38.

The very complicated digestive canal of the Bryozoa floats freely in the spacious cavity of their body. It is composed of an oesophagus which, at its lower extremity, dilates into a round or oval muscular crop; upon this immediately succeeds a caecal stomach, from the upper portion of which a small intestine arises and passes upwards in front. This, after a course of variable length, ends by a constriction in a short but large rectum, which opens in the vicinity of the mouth, at the external side of the base of the tentacles. The digestive canal here, therefore, is not in communication with the cavity of the body. Its whole inner surface is lined with very active, ciliated epithelium, which keeps its contents in motion, and especially the faces of the rectum. The sides of the stomach are often colored brown, yellow or green, from the presence of hepatic cells.

### CHAPTERS VI AND VII.

### CIRCULATORY AND RESPIRATORY SYSTEMS.

§ 39.

A vascular system has yet been found only with a few Polyps; but there it is so apparent that its presence in others may be inferred. The blood-vessels exist upon both the sides of the body and of the stomach, and are in part longitudinal, in part circular, ending in a capillary net-work. They are not simple canals excavated in the parenchyma, but have proper walls, and circulate a liquid containing a great number of white (blood) globules.

juice of the Anthozoa must have a very great digestive power, since the Actinia eat hard-shelled crustaces, and even the soft Hydrae quickly dissolve the larvae of Nais and Chironomus. But the indigestible parts of these animals, such as epidermata, bristles, hooks and jaws, are afterwards ejected by the mouth.

1 In Brownebankia (Farre, Phil. Trans. 1837, p. 392, Pl. XX. fig. 3; Pl. XXI. fig. 7) this crop is composed of pyramidal corpuscles, with the apices pointing inward, so as to act like teeth. I have observed a very similar structure in Aloyネタilla staznorum.

2 In Brownebankia and Vesicularia the small intestine is very long (Farre loc. cit. Pl. XX. and XXI). I have observed it very short with Cris-tatellus mirabilis.

* [§ 38, note 2.] According to Allman (Report Brit. Assoc. 1859, p. 510), the osophagus succeeds the stomach without the intervention of any distinct crop with all the fresh-water Bryozoa. The stomach is large and thick-walled, and may be divided into a cardiac and a pyloric portion. The pylorus is distinctly valvular, and the intestine, wide at first, passes along the side of the cardiac cavity and oesophagus, and rapidly decreases in diameter, until it terminates in a distinct anus just below the mouth. — En.

† [Note at end of § 38.] See in this connection my note under § 15, note 2. — Ed.
§ 40.

All Anthozoa and Bryozoa have a proper circulation; for there rises and falls in the cavity of their body a liquid, which is usually clear, and often contains round and colorless corpuscles. This rises even to the end of the cavity of the tentacles, and then returns into that of the body generally. In the colonial Polyps, these currents, by traversing the canals of the corallum, thereby pass from one animal to another. This movement is caused by ciliated epithelium, which, as we have just seen, lines all the cavities of these animals.

With the Bryozoa, the cavity of whose stomach does not communicate with that of the body, these currents are continuous, regular, and have a definite direction. But with the Anthozoa they are changed by the reciprocal action through the stomachic orifices of the liquids of the stomach and cavity of the body. These currents are perceived in the arms, even when the cavities of these organs open directly into the stomach.\(^b\)

§ 41.

Nothing can yet be positively said as to the nature of this circulating liquid, for it is still doubtful whether this whole phenomenon should be regarded as an aqueous or a sanguineous circulation. If we refer to the fact that the Anthozoa can introduce water into the system through the apertures of the stomach, it should be admitted that this system has an aqueous character, performing, perhaps, the function of an internal respiratory apparatus.

given off from the eight principal longitudinal vessels numerous lateral branches, which anastomose frequently in the canals of the corallum, and finally form a capillary net-work. The white, semi-transparent corpuscles contained in thin blood have, according to Will, a diameter of about 1-1200 of an inch, and out of the vessels have a globular aspect. According to this same observer, there is a similar vascular system in *Actinia.*\(^1\)

\(^1\) The circulation in question has been observed by many investigators. Trembley (Mém. pour servir à l'Histoire des Polypes, p. 219) has perceived it in *Plumatella cristata.* Dumontier (Mém. sur l'Anat. et la Physiol. des Polypes, p. 47) has confirmed this observation. Cavolini (see his Memoir on the Anthozoa, p. 66, 87) has seen it in the tubes of several Sertularia. There are various opinions as to the cause of these currents. *Grauhuisen* (Lexi. 1828, p. 600) studied them in the arms of *Hydra,* and regarded them due to a communication with a circular vessel surrounding the mouth. But, according to the observations of Meyen (Brown's Miscellaneous Botanical writings, IV, p. 430), of Ehrenberg (Mitchell. aus. d. Verhandl. des Gesellsch. naturi. Fremale. x. Berlin, 1836, p. 27) and myself, the cavities of the arms open directly into the stomach.

The movements of the liquid in the arms of *Hydra* are due not only to the general contractions of the body, as Grauhuisen and Meyen have supposed, but also to the cilia covering these parts. This was first pointed out by Grant (The new Edinb. Phil. Jour. 1827, p. 107) and of Comp. Anat. 1841, p. 430), who observed these currents in *Flustra, Lokularia, Virologula,* and *Pennatula.* Nordmann, who has examined this circulation in the body and tentacles of *Alcyonaria diaphana,* and *Plumatella campanulata,* and other Bryozoa, have not found any cilia. He compared these currents to those seen in the joints of Chara (Micreg. Botrac. H. p. 75, or Observ. sur la Faune Pontique, p. 70). I feel positive about the presence of cilia in the body of *Crassatella mirabilis* and *Alcyonaria stagnorum.* Later has carefully described this circulation with *Tubularia, Sertularia* and *Campanularia,* and finding no adequate cause, has likened it to that of Chara (Phil. Trans. 1834, p. 366, et seq.). Ehrenberg (Abhandl. d. Berl. Akad. 1832, p. 259) and Loven (Hiceman's Arch. 1837, p. 245) attribute these currents in *Sertularia* and *Campanularia* to a peristaltic movement of the canals of the body; which, however, Van Beneden (Mém. sur les Campii, loc. cit. p. 18) has been unable to see in these Polyps. Erdt (Muller's Arch. 1841, p. 428) attributes it, in *Portheus cyanomorium,* to cilia; and Will (Froenic. neues Notizien, 1843, No. 550, p. 68) has found all the cavities of the body and corallum of *Alcyonaria palmatum* lined with cilia. It is, moreover, certain that the currents observed by Erdt (Muller's Arch. 1841, p. 428) and Dumontier (Mém. loc. cit. p. 62) in the tentacles of *Actinia* are due to ciliary action.

\_*\) [§ 29, note 1.] Subsequent researchers have failed to detect any true circulatory system with the real Polyps, and there now can be but little doubt that no such system exists. As with the Analephs, their nutritive and digestive systems are combined; and, as with them also, the circulating nutritive liquid is chyme. See also Dana loc. cit. p. 35.

—Ed.
while the tentacles, in the cavities of which are regular currents, serve as external organs of respiration, similar to branchiae.

But, if we regard the whole as a true circulation, the contained liquid with its corpuscles will be analogous to blood. But this view is opposed by the fact that, with *Aleyonium*, with *Actinia*, and perhaps many other Polyps, there is a true vascular sanguineous system.\(^1\)

We ought, therefore, to compare the liquid in question to chyle, which passes from the stomach to the general cavity of the body, in the Bryozoa by exosmosis, but in the Anthozoa by the orifices of the stomach.\(^2\)

The opinion that these currents form a vascular system, moreover, is not reconcilable with the fact that the Anthozoa can at will empty the contents of their stomach into it, or in the same way shut off from it the water.

We are obliged, then, to regard all these cavities as constituting a vascular aqueous system, performing a respiratory function, by which, in the Anthozoa, all the internal parts are constantly bathed with fresh water. This renewal of water is effected by its alternate ingress and egress through the stomach,\(^3\) during which chyle-corpuscles could easily, by being mixed with water, be carried into this aqueous system.

With the Bryozoa, where this system is, without doubt, equally one of respiration, we shall have to seek for the openings by which this renewal of water takes place. These are situated near the anus, and place the cavity of the body in direct communication with the external water.\(^4\)

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\(^1\) See § 39, note 1.

\(^2\) Ehrenberg and Loven regard the canals of the coralluman of *Componataria* and *Sertularia* as direct prolongations of the stomach, and designate them as intestinal tubes, and their contents as chyme.

\(^3\) This alternate ingestion and egestion of water has been positively observed by Lister, Loven and Van Beneden, in *Sertularia* and *Tubularia*.

\(^4\) By an opening of this kind, Meyen (Ists 1828, p. 123) saw escape the eggs of *Aleyonella stagnalis*, which were free in the cavity of the body. Van Beneden (Ann. d. Sc. Nat. XIV. 1849, p. 222) declares that he has observed at the base of the tentacles of *Aleyonella* a series of orifices, which may be called *aquiferous mouths*, for by them the water enters the cavity of the body. This is perhaps the case with *Actinia*, also; for Rapp (Oeb. die Polyphen u. die Actinien, loc. cit. p. 47) has here found numerous small orifices scattered over the whole surface of the body, and through which are emitted jets of water when the animal is squeezed, thus showing that they belong to an aqueferous system. It is quite improbable that the hollow tentacles of *Actinia* are open by an orifice at their apex for the circulation of water, as many naturalists have supposed. *Quatre-fages* (Ann. d. Sc. Nat. XVIII. p. 96) is quite opposed to this opinion. See also above § 38, note 1.

\[^{[\text{End of § 41.}]}\]

In this connection should be mentioned branchia-like organs, described by Dana (loc. cit. p. 42) with the Zoanthids. A pair of them is attached to each of the larger lamellae. He remarks, "The structure of these organs is such that we can hardly doubt their branchial nature; yet no circulating fluid was detected within them."

I find no other mention of these parts, except by Lamour (Jour. Acad. Nat. Sc. Philad. I. 183–185, Pl. VIII. fig. 1, 5, 9), who regarded them as of an hepatic nature. — Ed.

\(^1\) [§ 41, note 4] The true nature and relations of the respiratory and circulatory systems of the Bryozoa are yet imperfectly understood. There can be but little doubt that water is by some means introduced into the general cavity of the body, and there mingles with the nutritious fluid, which transudes through the walls of the alimentary canal. But the apertures for the introduction of this water have not yet been clearly seen. It is true that Van Beneden thinks he has found "Bouches aquiferes," as above mentioned, but their existence there has not been fully verified, and is even denied by Allman. At present, therefore, it cannot be said that the Bryozoa have a true aqueferous system, like the Anthozoa. The perigastric fluid is, separated from the water, most probably the elaborated product of digestion, and the corpuscles therein contain chyle-corpuscles. Allman's view, therefore (Report Brit. Assoc. 1859, p. 319), appears the most correct: "The perigastric circulation, therefore, unites in itself the triple function of a chyliferous, sanguiferous and respiratory system." — Ed.
CHAPTER VIII.

ORGANS OF SECRETION.

§ 42.

Nothing like urinary organs have yet been found in Polyps. Perhaps the borders of the mantles of the cellular Polyps should be regarded as organs of special secretion, since by them the increase and production of these cells take place.  

CHAPTER IX.

ORGANS OF GENERATION.

§ 43.

Polyps reproduce by gemmation, fissuration, and by eggs.

1. **Fissuration** is comparatively rare; it takes place nearly always longitudinally, and the division may or may not be complete.  
2. **Gemmation** is their most common mode of reproduction. The new individuals may be completely detached, or may remain connected with the parent corallum.

a: In gemmation, complete separation of the young individual is, on the whole, rare. It is best known in *Hydra*, with which the buds always appear upon a certain part of the body,—that is, at its union with the foot. A bud of this kind consists always of a simple fold of the wall of the stomach and the skin, so that the stomach of the young individual is in direct communication with that of the parent, and the chyme can pass freely from one to the other. When the foot of this new being has acquired a proper development, it is completely detached at its inferior extremity.

b: Gemmation without separation of the new beings is quite common with Polyps, and occurs with very various modifications. The buds are formed sometimes upon the sides, sometimes upon the base of the body. In the first case, the coralla have a dendroid aspect; in the second, they are more lamelliform, spherical or lapidisecond. These variations are not limited to certain genera or species, being often due to external influences,

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1 The calcareous tubes of *Turbinaria*, and the conicose ones of the *Scolopereus* and other Bryozoa, are, without doubt, secreted by the border of the mantle, as is true of the shells of mollusks.

2 According to *Rossett* (Inschungsblatt, III. p. 594, 823. Taf. LXXXIII. fig. 3), fissuration takes place transversely with *Hydra*. Longitudinal fissuration is principally observed with the *Monilifera*. When it is complete the cells of the corallum are definitely limited, as in *Astraea, Favia*, and *Caryophyllia*; but, when incomplete, the cells are branched, lobulated, and of irregular contour, as in *Agaricia, Macandrina*, and *Monticularia*, &c.

3. *Rossett* (loc. cit. III. Taf. LXXXV. fig. 2, 3, 5, Taf. LXXXIV. and LXXXVIII. fig. g, h, and Taf. LXXXIX. fig. 4). The exceptions to this rule, which are sometimes observed, are probably due to lesions of an accidental nature.
§ 44.

3. It is probable that all Polyps reproduce by eggs. This requires two kinds of organs, one to produce the egg, the other the semen. Both kinds, ovary and testicle, have already been described in many species.

Their distribution is quite varied. In some, the sexes are united in the same individual,\(^{(1)}\) in others they are distinct;\(^{(2)}\) with the colonial polyps the sexes are separate, and each colony\(^{(5)}\) may be composed of individuals which are androgynous, or those of one sex alone.\(^{(6)}\)

Some species are sexless, and remain so; but they produce by gemmation individuals of a particular character, which have sexual organs.\(^{(7)}\) These last, which have usually either a campanulate or discoid form, are separated from the corallum often before the sexual organs have been formed, and which they do not acquire until an advanced period of their lives. During this time they swim freely about, like the pulmo-grade Acalephae,\(^{(8)}\) for which, as well as for young Polyps, they are often taken.\(^{(9)}\)

§ 45.

That the relations just described really exist, may be learned from the following facts: In Coryne echinata and vulgaris, there are formed at their base, quadrangular and campanulate individuals, which lay numerous eggs.\(^{(10)}\) In like manner also, ovigerous capsules are formed about the base of Synocephus ramosa.\(^{(2)}\) In Coryne frtiliaria,\(^{(3)}\) the new individuals are completely detached and swim freely about, closely resembling Medusae. In this condition they are developed, and their eggs come to maturity.\(^{(11)}\)

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\(^{(1)}\) Escara and Flustra have a lamellated form when fixed to stones, shells, or the broad leaves of Algae; but are tubular when attached to the stems of plants. Aegonella stagnorum undergoes similar changes in the form of its corallum. It divides in a regular dichotomous manner (Eichhorn, Beitr. zur Naturgesch. d. kleinuest Thiere, Taf. IV; also Roesel, loc. cit. Taf. LXXIII. and LXXIV.), and in this form has been described under the name of Plumellata campanulata by Lamarck. But when a colony of these Polyps is fixed upon a stone or a sunken root, they commence to be developed in a dichotomous manner. But afterwards they become tapetaceous by the branches of both sexes interlacing each other. As the mass becomes more voluminous and dense, the tubes of the dead generation support those of the living. (See Lamouroux, Exposition, d\'est Genres de Parois des Polypiers, pl. LXXVI. fig. 5.) Under this form this Polyp has received the name of Aegonella stagnorum (see Rasipal, Hist. Nat. de l\'Aegonelle Buviaile).\(^{(2)}\)

1. Hydra.

2. Actinia.\(^{(3)}\)

3. Aegonella.

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\(^{(9)}\) According to Erdt (Fromel's neue Notizen, 1859, No. 243, p. 101) the corallum of Periculum eynaruniurn and Aegonum have always either male or female individuals above. Krön has perceived the same of Sertularia (Müller's Arch. 1843, p. 181).

5. Coryne, Synocephus and Campanularia.

6. Coryne and Campanularia.

7. Very striking, at least, is the resemblance of Van Beneden's (Mém. loc. cit. pl. 11.) figure of a free female of Campanularia sertulina and those of Sars (Beskrivelser, loc. cit, p. 28, Taf. VI. fig. 10) of small Acalepha, named by him Cyrturus octopunctota, and by Will (Hornie tegestinae, 1844, p. 68, Taf. II. fig. 3) as Cyrturus polyptya, 1. R. Hagens, 1831, p. 396, Taf. XI; also Jones, loc. cit. Tab. XXXIV. fig. 10.


According to Sars (Beskrivelser, loc. cit, p. 6, Taf. I. fig. 8), these remarks are also true of Corymorphus nutans.

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\(^{(11)}\) For a full account of the reproductive process with Polyps, and the most philosophical exposition of the relations of gemmation and its analogies and affinities with other developmental processes, see Dana, loc. cit. p. 83. No abstract can be given of such a work. — Ed.
The Campanulariae and Scutellariae produce at the end of their pedicels and branches elongated slender individuals. But in the angles of these branches, walls of another form, and containing many spherical individuals, are developed. In these latter, second or tertiary pods, which in Campanulariae generally occurs without a separation of the new individuals from the pericarp, while in Campanulariae it occurs it is after detachment has taken place.\(^\text{[10]}\)

§ 46.

In the eggs of polyps both a germinative medium and a test may often be seen. Frequent, however, both disappear in a very early period. The envelopes of the egg are usually of a simple, though sometimes of a complicated structure. The spermatie parietes are very active, and in some species are branched, in others composed of a solid body or head, as to which as opposed to a very delicate tail. Water does not appear to affect either their form or motion.

§ 47.

1. With these polyps which are not sexless, and whose alimentary canal hangs free in the cavity of the body, the sexual organs are situated in this last. They often escape attention, since they are scarcely at all developed except at the sexual epoch. Both ovaries and testicles frequently appear as thread-like bodies, which, being attached by one extremity alone to the stomach, move freely in the general cavity of the body. Sometimes, however, they are attached longitudinally by one of their borders, like a monocyte, the opposite border being free. In other cases, again, they are attached directly to the sides of the body.

The eggs and spermatic particles pass directly from the sexual organs into the cavity of the body. In Carchia having individuals of both sexes, fertilisation takes place in the cavities of their bodies, which connect with each other. With the others, however, the individuals of which are of one sex only, the surrounding water is the medium of fertilisation, by transporting the spermatic particles exsiccated to the eggs; and this being performed by the aqueous circulation before mentioned, impregnation takes place in the cavity of the body.

§ 48.6

The variations of the internal genital organs in the different families are as follows:

1. With the Bryozoa, a thread-like ovary and testis are suspended from the extremity of the stomach. In these organs are developed only two to four eggs or masses of spermatic particles, from cells arranged like a string of pearls.6

The eggs, of which the germinal vesicle and dot disappear at a very early period, are detached from the ovary before their shell is well formed, and are set in motion by the cells of the cavity of the body. Usually they are flattened, and at first enveloped by a thin and viscous membrane, which soon becomes thicker and darker, and has upon its borders a clear, and the posterior themselves are the components of the lower end of the body, exactly as in lower and higher animals. They resemble, indeed, as far as I can perceive, a separated ovulation, to which is attached a thin external part. The sexes of the body, when united together with the best powers, possess differentia of sexual import. Nevertheless it is generally (Porifera, Ascolini, Borellia, etc.) located outside (outside) animal, while among the Bryozoa it is long-standing with appendages. I cannot therefore agree with Brugia (Caryota, Ann. Sci. Soc. Zool. 1809, p. 497), in so far as development of some portions with these animals. — En.

6 See, for Astomiaceae Cypris, Mag. Zool., Reut. (13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26), and for Codonosus, Astomus, and Astomina, Proc. Zool. Soc. 1841, p. 30, etc. In Porifera, see H. E. P., p. 348, etc.
transparent ring. In Alcyonella and Plumatella, the eggs are of an oval shape, and of a dark-brown color. In Cristatella mirabilis, Dal. (Cristatella mucrodo, Cuv.), they are lenticular and clear brown, and have this remarkable peculiarity: (6) Upon both sides of the encompassing ring are a number of double-pointed hooks, which, at first, are imbedded in a gelatinous substance; but as this last is dissolved by water, they become free, and adhere to plants and other bodies. (3)

2. With many Anthozoa, having a cavity of the body, the sexual organs are attached in the form of bands along the external face of the stomach. These are numerous, and during the epoch of reproduction their free borders are often plicated, and have a botryoidal aspect. This form is quite apparent in the Actiniæ, where these organs are contained in separate chambers of the cavity of the body. (4) The same is true of the Edwardsia. (6) With Vereillium (6) and Alcyonium (6) these organs form mesenteric divisions which descendent deep into the cavity of the body.

3. In Alcyonium elegans (6) and Tubipora musica (5) these organs are attached to the internal surface of the cavity of the body, and have a plicated mesenteric form. (10)

§ 49.

The laying of the eggs takes place in different ways with those Polyps having internal sexual organs. With the Bryozoa it probably occurs through the openings near the anus. (3) With the Anthozoa, however, they pass into the stomach through its abdominal orifices, and thence are ejected through the mouth. In the viviparous Actinia, the young, developed at the base of the stomach, are expelled in the same manner. (2)

§ 50.

II. Many Anthozoa, which have no general cavity of the body, have external sexual organs. This is especially true of Hydra, where in the

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2 Raspeit, loc. cit. pl. XII. fig. 10-12; pl. XIV. fig. 4-8, and pl. XV. fig. 5.
3 Turpin and Gervais, Ann. des Sc. Nat. VII. 1827, pl. III. A. fig. 2-4, and pl. IV. A. fig. 1-4.
4 Wagner. Haeckel's Arch. 1835, I. Taf. 111. fig. 1, also loc. cit. Taf. XXXIV. fig. 22.
6 Carus and Otto. Erkterungstafeln, Heft IV. Taf. I. fig. 19, also Wagner. Icones zoot. Taf. XXXIV. fig. 2.
7 Milas Edwards. Ann. d. Sc. Nat. loc. cit. pl. XIV. fig. 4; pl. XV. fig. 6, 8, and pl. XVI. fig. 3-5.
8 Ibid. p. 529, pl. XII. fig. 3, pl. XIII. fig. 2-7.
9 Rymer Jones. Outlines. loc. cit. p. 36, fig. 9, after Lamouroux.
10 Kolliker's observation upon the sexual organs of Alcyonidium gelatinosum, Johnst. (Halobryozoa diaphanus de Parry), is quite remarkable; for he found them wanting in the isolated individuals, but scattered here and there, in the form of small round sacs, in the fleshy substance of the corallium—some being ovaries, others testicles. But he is in doubt whether or not their contents are emptied into the cavity of the body or upon the outer surface (Beitr. loc. cit. p. 40). 1
1 See, for Alcyonella stagnorum, Meyen (Ibis, 1828, p. 1228).
3 Rathke has often found spawn in the stomach of Actinia (Reise Bemerk. aus Pfannen, zur Morph. 1837, p. 10, and Beitr. zur vergl. Anni. u. Physiol. in den neuesten Schriften. d. naturf. Gesellschaft. zu Danzig, III. Hft. IV. 1812, p. 113).
§ 50. THE POLYPI.

same individual during the time of heat both ovaries and testicles are developed upon the external surface of the body.

In the place where the eggs are to appear, the transparent and colorless skin rises in the form of swellings, under which the vitelline mass gradually forms. These end each in the form of an excescence, which, being constricted at its base and rounded, has the shape of an egg. At the point of constriction there is formed from the body of the Polyp a kind of cupel, in the cavity of which the vitellus rests by a small portion of its surface; at this point the skin becomes thin, and ultimately appears like an arachnoid membrane enveloping the egg. In this last neither a germinative vesicle nor dot has been discovered. Its separation is preceded by a thinning of its surrounding membrane, after which the vitellus is immediately clothed by a gelatinous substance. In *Hydra vulgaris* its whole circumference is covered by obtuse prolongations of this kind, which, after an increase in length, divide, each one or more, at their extremity, and so present a dentated appearance.

The arachnoid membrane finally bursting, the detached egg becomes fixed to some body, whilst the gelatinous coat entirely disappears. This is equally true of *Hydra viridis*, with the exception that here the vitelline prolongations are very short and compact. (2)

In these same individuals testicles are developed also. Between the base of the tentacles and the place of the appearance of the egg, there are developed small conical prominences, on the apex of which is a papilla. This has an orifice which leads into an internal cellular cavity. This is the real testicle, wherein are found spermatic particles composed of a body, or head, to which is attached a very movable tail. These particles easily escape through the orifice, and circulate in the water surrounding the Polyps filled with eggs. (3) The number of these testicles in a single individual is not definite. (1)

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1. In the ann-polyps, germination always precedes propagation by eggs.
2. The eggs of *Hydra* were long ago observed by Bernhard Justisiu (Abhandl. d. schwed. Akad. 1740, VIII. p. 211). But afterwards they were regarded as exanthemata of this animal (see Roesel, Insektenbiust. Th. III. p. 599, Tab. LXX-XIII. fig. 1, 2). Their true nature was lately first pointed out by Ehrenberg (Abhandl. d. Berliner Akad. 1835, p. 116, Tab. II.).
3. The testicles of *Hydra* were known to the elder naturalists, but were taken for an eruptive disease (Trembisy Abhandl. zur Geschichte der Polygenes, p. 254, Tab. X. fig. 4, and Roesel, loc. cit., p. 502, Tab. LXXIII. fig. 4). Latterly this same error has been continued (Laurent in Pratie's neue Notizen, 1842, No. 513, p. 104). To Ehrenberg is due the first description of their true nature (Mettheil. aus dem Verhandl. d. Gesellsch. naturf. Freundes in Berlin, 1838, p. 14).

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4. Wagner, Icones zoeli. Tab. XXXIV. fig. 10, h. b. In *Hydra vulgaris* I have counted fifteen testicles; another individual had seven eggs and eleven testicles; and a third, four eggs and twelve testicles.

[Additional note to § 50.] Other examples of Anthozoa having external genital organs in the form of egg or sperm capsules have been observed by Van Beneden (Rech. sur Pemorphog. d'Island. p. V. VI.), Katteke (Wiedmann's Arch. 1844, 1. Tab. V.), and Sars (Fauna litoral. Norveg. p. 3, Tab. II.), with *Hydractinia, Coryne* and *Podo-coryne*. See also the facts collected by Frey and Lueckart (Bistri. Sci. p. 25). These egg or sperm capsules may, moreover, be regarded as imperfect male or female individuals, and then the porters of these capsules may be considered, being sexless individuals like those mentioned in § 45, in the category of nurse-like generations which, after a more or less complete development, produce generations with sex.

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* [At end of § 50.] The so-called ova, mentioned above in the text, may be justly questioned as being true ova, for we know of no real ova which do not contain a germinative vesicle. Then, again, simple oval masses of cells as they are, would exactly resemble the bud-like eggs of Aphides, and the "liberating eggs" of *Daphnia* and some of the Rotatoria, all of which are properly gammas, and do not require the agency of the spermatic particles for their development. It is also worthy of remark, in this connection, that these ova sprout from the same part of the body in which eggs are developed. Thomson, however (Edinb. New Philos. Jour. 1847, p. 217), speaks of having observed the granular mass contained within these so-called eggs divide and subdivide like a proper vitellus, and this while still within the capsule, and attached to the parent animal. This does not
III. There are Polyp-colonies which contain two kinds of individuals, those which are sexless, and those having sexual organs only at certain epochs. These last are campanulate or medusoid, and their sexual organs are developed in various parts of their body.

In Coryne (1) and Syncoryne, (2) the eggs appear upon the external surface of the stomach, then fall into the cavity of the mantle, through the openings on the border of which they escape into the water. In the medusoid individuals of Coryne fritillaria and Corynopsis mutans, the sexual organs appear to be formed in the angles of the borders of the disc, (3) and in Campanularia in the disc itself. *

§ 52.

As to the embryonic developments of Polyps, it is probable that in a great number (perhaps all) there is a metamorphosis.

The development commences by the usual segmentation of the vitellus, (4) by which it is ultimately converted into an ovoid, contractile body; this turns upon its longitudinal axis by means of cilia, with which it is entirely covered, swimming about like many Infusoria. These embryos, often developed in the mother, have sometimes been taken for swimming eggs. (5) Afterwards they attach themselves to some body, and usually lose their cilia; the free extremity of their body opens, allowing the escape of the Polyp, which, in the mean while, has been developed in the interior, with its arms in front. Many of the Polyps thus produced multiply by gemmation, and thus become the foundation of new Polyp-colonies. (6)

1 Wagner (Ibis 1833, Taf. XI. fig. 8). 2 Loven (Wiegmann's Archiv. 1837, I. Taf. VI. fig. 19, 20). 3 Steenstrup, Ueber d. Generationswechsel, p. 23, 24. 4 It is indeed singular that with Hydra the division of the vitellus takes place before the eggs are either detached from the body, or are surrounded by a dentated envelope. I do not yet know at what epoch the development of the embryo commences, for I have never seen the young come forth. It is impossible for me to say whether or not these Polyps experience a metamorphosis. Pallas (Karakteristik d. Thermophylax, p. 83) has seen the young Polyps come forth from the egg, but he gives no description. Laurent, also, only says that the young animal escapes formed from the egg, without describing the embryo (Froriep's neue Notizien, No. 513, pl. 101). The segmentation of the vitellus has been observed by Van Beneden in the eggs of Pedicellina. See his Rech. sur Pami. d. Bryozaires (suite) loc. cit. XIX. p. 18, pl. II.

As would be inferred from his description, Car- olini (loc. cit. p. 17, 59, Taf. IV. fig. 7-10 and 13-15) has observed similar embryos to those of Gorgonia and Madrepora. His descriptions of various eggs of Sertularella leave no doubt that they also make the matter any more clear; for, even admitting that they are proper ova, it is difficult to conceive how the impregnation (of which the segmentation for a definite result is the sequela) could take place while the ova are thus buried in the capsules. The subject requires further research. See also Steenstrup, Untersuch. ßb. Hermaphroditismus, p.

116, and Humeck, Ann. Nat. Hist. 1850, V. p. 282. — Ed. 5 [End of § 51.] See Schultze (Muller's Archiv. 1859, p. 57), who has found with Campanularia seminal capsules corresponding to those for egg-capsules pointed out by Loven (loc. cit.). — Ed.
This metamorphosis is completed when the skin is covered by a brown and solid layer, and new individuals are developed by gemmation from the two Polyps (See Megen, Isis, loc. cit.). I have seen the development of the coralla of Cristatella mirabilis and Plumatella campasulata occur in the same way. With the Cristatellae, gemmae of new Polyps are often seen to arise from the skin, even after the escape of the two Polyps, and before the young colony has become at all fixed. At this epoch of development these Polyps have been taken by Cuvier for a distinct species, and called Cristatella mucedo. See Roesel, loc. cit. p. 559, Taf. XCI.; and Turpin, Ann. d. Sc. Nat. VII. 1837, p. 65, pl. II. and III.

Infusoria-like embryos have been observed also by Steenstrup (Untersuch., loc. cit. p. 66, Taf. I. fig. 21) with Coryne aquamata, and by Sars (Faun. litoral. Norweg. p. 7, Tab. II. fig. 7-11) with Podocoryna carneus. The round eggs moving about by means of cilia, which Reid (Ann. of Nat. Hist. XVI. p. 592, 597, pl. XII. fig. 9, 10) has observed in the visceral cavity of Pedicelina echinata, and in special capsules with Flustra avicularis, were probably embryos also. *

* [§ 52, note 3.] The embryonic development of the Bryozoa has been carefully wrought out by Van Beneden. See Recherch. sur les Bryozoaires, &c., Mém. Acad. Bruxelles. XIX. See also Allman, Report, loc. cit. 1860, p. 322 — En.
§ 53.

The body of Acalephae is composed of a transparent, gelatinous substance, quite resembling the Corpus vitreum of the eyes of vertebrata. By desiccation it almost entirely disappears, there remaining only a dry cellular tissue, by which the form of the animal is imperfectly preserved. These animals swim freely in the sea after having attained their development.

In the arrangement of their organs in ray-like processes radiating from a common centre or a longitudinal axis, and where also is situated the digestive apparatus, the quaternary system prevails. Copulatory organs are always wanting. The classification is based, according to the system of Eschscholtz, upon difference of external form, and upon the structure of their digestive and locomotive organs.

ORDER I. SIPHONOPHORA.

They take in their food by means of numerous tubes, which exist in place of a stomach. Locomotion is aided, generally, by certain cartilaginous capsules.

Family: Diphyidae.
Genera: Diphyes, Ersaea.

Family: Physophoridae.
Genera: Physophora, Stephanomia.

Family: Physalidae.
Genus: Physalia.

Family: Velellidae.
Genera: Retaria, Velella, Porpita.
§ 53. THE ACALEPHAE.

ORDER II. DISCOPHORA.

They have a simple central stomach, and move by means of discoid or campanulate contractions of their body.

**Family: Acquorina.**
*Genera: Acquorea, Polyxenia.*

**Family: Oceanidae.**
*Genera: Oceania, Cytaeis, Thaumantias.*

**Family: Geryonidae.**
*Genus: Geryonia.*

**Family: Rhizostomidae.**
*Genera: Cephea, Cassiopea, Rhizostomum.*

**Family: Medusidae.**
*Genera: Pelagia, Cyanea, Chrysaora, Medusa, Aurelia, Ephyra, Stheno-nia.*

ORDER III. CTENOPHORA.

Their mouth and stomach is simple and central, and they move by means of cilia arranged in longitudinal rows.

**Family: Beroidae.**
*Genera: Beroe, Lesueuria, Medea.*

**Family: Mnemiadae.**
*Genus: Eucharis.*

**Family: Callianiridae.**
*Genera: Cydippe, Cestum.*

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Also, Twelve Lectures on Comparative Embryology, delivered before the Lowell Institute, Boston, 1848–49.


[The above are among the most important larger works; but see, also, many papers of great value, to which I have referred in my notes.—Ed.]

CHAPTER I.

SKIN AND CUTANEOUS SKELETON.

§ 54.

Generally, the body of the Acalephae is of a gelatinous substance, composed of polyhedral cells. In some species certain parts of the body have a cartilaginous hardness, but it is only in a few that there is found a cartilaginous or calcareous nucleus, comparable to a rudimentary skeleton.

With the Diphyidae a large portion of the body has a cartilaginous density, and with the Physophoridae it is often surrounded by plates of a similar nature. The Vellellidae have a nuclear skeleton, which in Rataeria is a simple, elongated disc; but in Velella this disc, which is horizontal and of an elongated oval form, is surmounted by a vertical crest. The disc is composed of four pieces joined together by two sutures which cross each other obliquely. The crest, united to the disc along the whole length of the two sutures, and resembling the segment of a circle, is composed of two main pieces, joined in the middle by a third, which is shaped like a wedge.10

The disc situated under the skin of the upper surface of Porpita, and

1 Eschscholtz, loc. cit. Taf. XV.; and Lesson, Acalèphes, loc. cit. Pl. XII. fig. 1; also, Duperrey, Voyage loc. cit. Zoophytes, No. 6. fig. 1, A. A.
which encloses between its two lamellae numerous aerial canals, is said to be of a calcareous nature.\(^2\)

All these discs have upon their surface markings of concentric rings and diverging rays.

\section*{§ 55.}

The Acalephae are surrounded by a very delicate epidermis. Upon various portions of the body, and especially upon the arms, the tentacles, the prehensile filaments and the cirri, there exist cilia and peculiar netting and prehensile organs. In those species having active irritating properties the netting organs are situated in a mass under the epidermis.\(^1\)

\section*{§ 56.}

These netting organs are generally composed of an oval capsule, containing a spiral filament which is thrown out from the slightest disturbance, and, together with its capsule, is detached from the skin.\(^1\)

In some species, there exist in place of these netting organs others of a prehensile nature, consisting of an oval capsule in which is a stiff bristle. These last cause no burning sensation, but are the means by which these animals attach themselves to contiguous objects in a bur-like manner. They are situated, grouped in small masses, under the skin of most of the non-netting Discophora, and their bristles project upon the cirri situated upon the border of the disc, upon the tentacles, the arms and the sexual organs.\(^2\)

\begin{footnotesize}
\begin{enumerate}
\item Enchebroth, loc. cit. p. 176, and Lesson, loc. cit. Pl. XII. fig. 2; also, Duperrey, loc. cit. No. 7, fig. 3.
\item Wagner (Muller's Arch. 1847, p. 183, Taf. VIII. fig. 4, b) has described the peculiar hair-like productions on the sides of Beroe and Clypeis. They have, near their free extremity, a multitude of pedunculate small buttons, inserted on a clavate swelling.
\item Wagner (Icon. zool. Tab. XXXIII. fig. 8, 10; 11, A. B. C. and Uber den Bau der Pelagia noctiluca, 1841; also, in Wiegmann's Archiv 1841, Th. I. p. 39) has found in Pelagia noctiluca that the netting capsules are situated among the pigment cells beneath the epithelium of the disc. According to this author, Oceanio, which has feebly netting powers, has these capsules only upon the marginal filaments. Ehrenberg (Wiegmann's Archiv 1841, Th. I. p. 71, Taf. III.) has failed to find these organs upon the non-netting disc of Cyprea capitata, although they are found among their prehensile cirri, which have irritating power.
\item With these, as with the hooked organs of Hydra, he thought the capsule was detached before the filament. Will (Iora longes, pp. 62, 65) did not find these organs in Cernea, except upon the tentacles of the genital organs; and in Polyxenia only on the marginal filaments. Kolliker (Beiträge, loc. cit. p. 41) has seen them also about the genitalia of Chrysaora and Aequorea.
\end{enumerate}
\end{footnotesize}

* For these netting organs and their intimate structure, see my note under § 27, note 1.—Ed.
CHAPTER II.
MUSCULAR SYSTEM AND ORGANS OF LOCOMOTION.

§ 57.

The Acalephae have a distinct muscular system. Their contractile substance is composed of a net-work of elongated, slender filaments and bands; these, in the urticoid species, are arranged in a longitudinal and annular manner, but in those of a discoid and campanulate form they are disposed in a circular and radiate manner.

In the extremely irritable tentacles and tactile filaments, the longitudinal fibres abound. 1

Each fibre is smooth when relaxed, but during contraction appears transversely wavy and plicated. 2

§ 58.

The contractile and aërial natatory vesicles, which are found in the Physothoraceae, 3 and the movable lamellae of the Ctenophora, may well be regarded as accessory organs of locomotion. These last, which are arranged in rows upon the sides of the animal, and which by some anatomists have been regarded as respiratory organs, are not simple cutaneous lobes, but are composed of very long cilia closely united together, and the motion of which is voluntary with the animal. 4

1 *Will* (loc. cit. p. 48, Taf. I. fig. 11) has observed in the contractile exocranialis of the *Eupharsis*, not only circular fibres and numerous longitudinal muscles, but large transversely-thickened ones, which were found to play by oblique bands.

2 *Will*, loc. cit. p. 47, 65, Taf. I. fig. 13. According to Wagner (Ueber den Bau, sec. 3 and Icon. com. Taf. XXXIII. fig. 36), the muscles of the Discophora have always the transverse stripe.

The cartilaginous natatory pieces of the Siphonophora play a completely passive part in the act of locomotion. The swimming is exclusively performed by the energetic contractions of the muscular membrane which lines their cavity, constituting, therefore, a true natatory sac. See Sars Faun. Litoral. Noreg. p. 42. 5

3 Lately, it has been doubted if the Physothoraceae can sink and rise in the sea by means of their natatory bladders, because they cannot exhaust the contained air. According to Oferus (Abhandl. d. Berl. Akad. 1831, p. 157, 155, Taf. I.), there are two of these bladders in Physaulus, one of which only has an opening. *Philippi* (Müller's Arch. 1843, p. 62) has found neither internal nor external opening to the bladder of Physophora tetrasticha. In Stephonoma it would not appear, according to the description of Milne Edwards (Ann. d. Sc. Nat. XVI. p. 218, Pl. VIII. fig. 1, b. 2), that this organ had an external opening. *Couch* (Pensel's neue Notizen, No. 272, 1830, p. 129) denies that Physaulus has the power to control the air of its bladder. See also below, § 65.


* § 57, note 2. For the muscular system of the Acalephae, see also Forbes (loc. cit. p. 3), and Agassiz (loc. cit. p. 230). This last-named author has described this system with full details in many genera. It is much more complex than has hitherto been supposed, and I must refer for the details to the memoir in question.

In regard to the structure of these muscles, *Agassiz* remarks: "With all the power of the best *Oberhauser* Microscope, I have been unable to discover the slightest indication of strie on the muscular cells; nevertheless, it cannot be doubted that they are voluntary muscles." To this view I may add my own of the same nature.—Ed.
CHAPTER III.

NERVOUS SYSTEM.

§ 59.

A nervous system has been found in many Acalephae. With the Ctenophora the oesophagus is surrounded by a ring formed of eight ganglia, and at the opposite extremity of the body there is a simple ganglion. Five nervous filaments pass out from these ganglia, and along the sides of the body are nervous fibres, which ultimately divide into delicate threads.

The tentacles of Medusae are supplied with nervous filaments which issue from a ganglion situated at their base.

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CHAPTER IV.

ORGANS OF SENSE.

§ 60.

With many Acalephae, there are, upon the borders and extremities of

1 These eight ganglia, which are connected together by delicate cords, were first observed by Grant (Trans. Zool. Soc. Lond. I. p. 10) in Cydippe pilum. Compare, also, Wagner, Mem. zool. Tab. XXXIII. fig. 37, A. B. From each of these ganglia two nerves pass off to the side, while a third, traversing the interior of the body, and having two or three swellings, is finally distributed to the intestine. Patterson (The Edin. new Philos. Jour. XX. p. 26) and Forbes (Ann. of Nat. Hist. 1838, p. 148), have also observed the cephalic ganglia in Cydippe, but did not perceive the ganglia.

2 Milne Edwards (Ann. des Sc. Nat. loc. cit. p. 206, Pl. IV. fig. 1) has observed at the posterior extremity of the body of Lesseunia citrina (a new Berol) a ganglionic body which sends out in front four filaments; and upon the sides of this animal a nervous cord, from which pass off delicate branches at regular intervals. At the posterior extremity of the body of Cydippe, Eucnemis and Medusa, Will (Froriep's new Notizen, No. 593, 1843, p. 67, and Horne tergest. p. 44) has likewise observed a round, yellowish ganglion, with four prolongations, from which pass off twenty-five or thirty nerves.

3 Ehrenberg has found along the entire border of the disc of Medusa aurita, and between each two tactile filaments, a bid nervous ganglion. He affirms to have seen also two others similar, at the base of each tentacle surrounding the genital organs. See Abhandl. d. Berl. Akad. 1835, p. 206, Taf. IV. fig. 1 x.; and Muller's Arch. 1834, p. 571.

* § 59, note 3.] The nervous system of the Acaleph has been successfully studied by Agassiz upon several genera (Hippocrene, Thiaropsis, Staurophora). His results are new, and different from those of previous observers. I cannot do better than to quote his words: "There is, unquestionably, a nervous system in Medusae, but this nervous system does not form large central masses, to which all the activity of the body is referred, or from which it emanates. There is no regular communication by nervous threads between the centre and periphery and all intervening parts; and the nervous substance does not consist of homogeneous elements, of nervous globules and nervous threads, presenting the various states of complication and combination, and the internal structural differences, which we notice in the vertebrated animals, or even in the Molusca and Articulata."
their body, button and tongue-like organs, which, as they are connected with neighboring ganglia, may well be regarded as organs of sense.

Their essential structure is a membranous capsule, containing a clear liquid, in which are suspended crystalline corpuscles.

These organs, having sometimes a red pigment, have been taken for eyes; but, as most of them are without pigment, and as the crystalline corpuscles behave in acid like the Otolites of the higher animals, they have more recently been better designated as organs of hearing.

The eight marginal, tongue-like bodies, found upon the disc of Medusa aurita, have been regarded as eyes. The sole fact for the support of this opinion is the presence of pigment; for the small hexagonal crystals, irregularly scattered in the interior of these bodies, would scarcely allow them to refract the light like a crystalline lens.

The Ctenophora have only a single organ of this nature, and which is situated near the ganglion at the posterior end of the body. It has been regarded both as an eye and as an organ of hearing.

With many Discophora, these organs appear as pale-yellow, or even colorless marginal corpuscles, having more or less calcareous bodies.

It is yet doubtful whether the otolites of the Aculeaphae perform the same movements as those of the accephalous and gastropod mollusca.

1 These marginal corpuscles, already observed in the Medusae by Gäde (Beiträge zur Anat. u. Phys. der Medusen, 1816, p. 18, 25), and by Korsen- thol (Zool. f. Physiol. 1. H. 2, 1829, p. 229), were first described as eyes by Ehrenberg. See Müller's Arch. 1834, p. 571, and Abhandl. d. Berl. Akad. 1835, p. 194, Taf. IV. V.

2 Milne Edwards has called this body, in Leuc- curia vitrea and Beroea Forskalii, 'Organe ou- liforme' (Ann. d. Sc. Nat. loc. cit. p. 206, 211, Pl. IV. fig. 1, k, and Pl. V. fig. 4, l.). According to Will (Ferrie's neue Nat. No. 599, p. 67, and Horse tergest. p. 45, Taf. 1. fig. 2, 4, 29, b.), the red pigment of these organs is entirely wanting in Beroe, Eucharis and Cydippae, while the hexagonal calcareous corpuscles are very numerous—a fact leading him to conclude that these organs are auditory vesicles.

3 According to Wagner (Über den Bau, &c., and Icon. vorst. Tab. XXXIII. fig. 31, p. 24, &c., and 25), these corpuscles are pale-yellow in Pelagia noctiluca, and colorless in Oceanus, Cassiopea and Aequorea. In Cerana, Will has observed only pale-yellow corpuscles, filled with crystals. And, according to him (loc. cit. p. 64, 65), the colorless pedunculated marginal vesicles of Polyzoaria lev- castyta contain, each only a single round stile, while those of Cerana polygalta contain numbers, colorless or yellow, and of irregular forms. He has also observed (loc. cit. p. 72, Taf. II. fig. 9, 10) that in geryonia the number of these otolites varies from one to nine. Milne Edwards (Ann. d. Sc. Nat. XVI. p. 196, Pl. 15., c.) has observed upon the margin of the disc of Aequoraria violacea vesicles containing two or three spherical corpuscles, and which, probably, are auditory organs.

According to Sars (Wiegmann's Arch. 1841, Th. I. p. 14, fig. 60), and Will (loc. cit. p. 75, Taf. II. fig. 21, A, B.), these marginal corpuscles are found upon young Medusae belonging to Ephyra.

4 Will has never observed with the Otolites of Aculeaphae similar movements to those of mollusca. Kükeler (Ferrie's neue Nat. No. 534, p. 82) has observed vibratile cilia upon the inner surface of the marginal corpuscles of Pelagia, Cassiopea, Rhizostomum and Oceanus, which are pyramidal, and contain many calcareous crystals. In the pedunculated vesicles of Geryonia, which contain only a single stile, these cilia are absent. In none of the Medusae has he found collections of pigment, and in Oceanus (nov. spec.) only he has observed a mass of brown pigment cells upon the external and superior surface of the base of these corpuscles; in the centre he perceived a round transparent body, and upon the upper surface a circular opening, so that the whole closely resembles an eye, there being, moreover, a kind of papilla- lary opening, and the traces of an ophic nerve from a ganglion.

According to the observations of Frey and Leuckart (Berl. &c. p. 69), the group of otolites contained in the auditory organ of a Ctenophora perform oscillatory movements, due evidently to vibratile cilia situated on the auditive capsule.*

* [§ 500, note 4.] The organs of sense of the Aca- lephae have been the objects of much study of late, and to Aequoraria we are indebted for the most minute researches on these obscure points. He has shown the eye-specks to be undoubted organs of sense, forming homeocrin with the nervous system. With the naked-eyed Medusae, he regards them light-perceiving instead of auditory organs. In regard to the single organ found with the Cteno- phora, and which Frey and Leuckart have re-
The digestive apparatus of the Acalephae is formed after several very different types. The mouth is sometimes single and central, or there may be many of them. It is often surrounded with arms and retractile filaments, which are endowed with the prehensile and netting organs just described.

The digestive cavity, which is always lined with ciliated epithelium, has distinct walls, which are united immediately to the parenchyma of the body, leaving, therefore, no surrounding cavity.

With those having a single mouth the stomach is of a variable size, and has often caecal appendages. With Beroe, the mouth is very large and free from tentacles, and opens into a very spacious stomach which occupies nearly the whole body. But with Cestum, Cyclope and Lesueuria, the stomach is small, and appears like a cavity in the body; and with Cytaeis, Thaumantis and Geryonia, it is likewise small, and has the shape of a tubular projection.

That of Medusa has four saccular folds, that of Pelagia six, and that of Cyanea thirty-two.

When the mouths are numerous, either, as in the Rhizostomidae, there are many canals which conduct the food through the arms upon which the mouths are situated into the central stomach; or, as in the Siphonophora, each mouth opens into a particular tubular stomach. With these last, however, a certain number of their tentacles are hollow, and have a mouth at the extremity. As it has been observed that these suck in food and digest it, their orifices have been regarded as mouths, and their cavities as stomachs.

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2 Escherich, loc. cit. Taf. I. II. ; and Milne Edwards, loc. cit. Pl. III.
3 Willi, loc. cit. Taf. II.
5 Wagner, Icon. zoet. Tab. XXXIII. fig. 5.
6 Gaecke, loc. cit. Taf. II.
7 Eysenhardt, Nov. Act. physico-med. X. part II. p. 591, Tab. XXXIV. fig. 1 (Rhizostomum Cuvieri). 8 This is so, for examples, in Diphyes (Will, loc. cit. Taf. II. fig. 22); in Physalia (Offeris Abhandl. d. Berl. Akad. 1831, p. 162, Taf. 1); in Strophania (Milne Edwards, Ann. d. Sc. Nat. XVI. Pl. VII. X. X.); and in Physophora (Philippi, Muller's Arch. 1843, Taf. V. fig. 1, 4).

(LOC. CIT. P. 316.) On a preceding page he says: "That this may be the case seems probable when we consider the relation of the two sorts of apparatus in the two types. The upper nervous ring in Sarsia bears the same relation to the central alimentary cavity, and to the pigmented disc, that the ganglion and eye-speck of Beroe bear to the chymiferous system, which opens above its gelatinous disc, notwithstanding these openings." (P. 248.)

This point, fully as interesting from its zoological importance as from its morphological relations, can be settled only by a knowledge of the embryology of these animals. — En.
The Acalephæ have no true digestive tube. But, as such, has been regarded a system of vascular canals filled with water, and which, departing from the stomach, traverse the whole body. But these, although sometimes seen to contain fæces, seem to belong more properly to the respiratory system.\(^9\)

In none of the Acalephæ has there been found anything like an hepatic organ.\(^9\)

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**CHAPTER VI.**

**CIRCULATORY SYSTEM.**

\(\S\) 62.

Until lately, the longitudinal and circular canals which, in some Acalephæ, are spread out through the entire body, have been regarded as belonging to a vascular, sanguineous system. But more recently these have properly been considered as aquatic-respiratory organs, there having been found, moreover, other vessels of exceedingly thin walls, and of a sanguineous nature.

These last constantly accompany and surround in a tubular manner the aquiferous canals; and it is quite rare that small branches are distributed to the general parenchyma.

The delicate walls of these vessels have neither longitudinal nor circular fibres, neither are they lined with ciliated epithelium. They circulate a

required to thoroughly settle this point. See below, the respiratory organs. See also Hotard, who

unhesitatingly regards the canals, which, with \(V\)ecellia, communicate externally by a central opening, as a digestive cavity, and thinks he has observed in their walls brownish spots representing the hepatic cells; see Ann. d. Sc. Nat. III. 1845, p. 293, Pl. IV, fig. 1.

\(^9\) The aquiferous canals of the respiratory system having been regarded as intestinal tubes, their orifices, which in the Ctenophora are situated at the extremity of the body; and in the Discophora upon the borders, have been considered as anal openings; and especially so, since in these two orders accidental fæces in these canals are expelled through these orifices. See Will, loc. cit. p. 25, and Ehrenberg, Abhandl. d. Berl. Akad. 1835, p. 189, Taf. I. IV. fig. 2, z.*

\(^9\) Acalephæ possess an extraordinary digestive power, which is the more singular as no secretory organ has been found on the sides of their stomach. Mertens (Mit. d. Acad. de Sc. Petersbarg, loc. cit. p. 430, Taf. 1. fig. 5, 6, a.; and p. 518, Taf. VIII. fig. 4, Taf. IX. fig. 1, 4) however, admits to have seen in Cestum and Cystippe four vessels in this situation, which are perhaps hepatic organs. The orange-colored canals found upon the sides of the stomach of Stephonomia, and which Milne Edwards (Ann. d. Sc. Nat. XVI. p. 222, Pl. VII. IX. X.) has taken for genital organs — may they not also be hepatic organs?"

\(\*\) [§ 61, note 9.] Upon the nutritive system of the Acalephæ, see Forbes (loc. cit. p. 4), but especially Agassiz (loc. cit.), who has studied the subject with considerable care. There is no distinction between the alimentary canal proper and the vascular system, for the one opens by large tubes into the other. The Acalephæ, therefore, circulate chyme, and here we have the rudest form of circulation. If this idea is once well considered, the relations of their nutritive apparatus in general will be quickly appreciated.

The variations in the shape and form of the digestive apparatus are wide and numerous, but their importance is rather in Zoology. See Agassiz for the details of Sarina, Hippocrene, Tiaropsis, Staurophora, Pterobranchia, Loligo. — Ed.

\(\text{[§ 61, note 10.] Kolliker} (\text{Siebold and Kolliker's Zeitseh. IV. III. 3, 4, p. 318})\) has observed with \(V\)eclita and Porpita a glumular mass, corresponding most probably to a liver. It had before been regarded as such by \text{Delle Chiare}, but Kolliker has given it a special description. It consists of a brown mass which communicates with the bottom of the stomochial cavity by branched, anastomosing ducts. — Ed.
colored fluid and colored corpuscles; and these corpuscles are not found except in those vessels surrounding the aquiferous canals.

There is no regular circulation, but the shifting motion of the blood hither and thither is due to irregular contractions of various parts of the body. 1

**CHAPTER VII.**

**RESPIRATORY SYSTEM.**

§ 63.

The entire body of the Acalephae is traversed by canals which receive water from the stomach, or directly from without, and which is ejected through openings upon the extremity of the body and on the margin of the disc.

These aquiferous canals are lined with a delicate, ciliated epithelium, by means of which accidental particles of food or fæces are quickly removed. They have been regarded both as digestive and as sanguineous organs. But that they are respiratory organs is highly probable, not only from their structure,—the cilia producing a constant renewal of water,—but also from the fact that they are surrounded by real sanguineous vessels.

This aqueous circulation is oscillatory from one side of the body to the other, being interrupted only by those contractions of the body which occur when fresh water passes from the stomach into the canals. 2

1 These new details upon the sanguineous system of the Acalephae are due to Will (Hermes tert. p. 34, and Frørstrup's neue Nat. No. 90, 1844, p. 86). In Herce, he has been able to clearly distinguish the sides of these vessels from those of the aquiferous canals contained in their interior, for the first are covered with numerous red pigment cells.

The blood of this animal has a greenish hue, and contains spherical or slightly elongated red corpuscles, with large nuclei. But, beside these, Will has found in Cydippe other nucleated cells of a greenish color. In Polypedia, there is no sanguineous system separate from the aquiferous canals, which, in Cydippe and Geryonia are quite surrounded by them. The vessels of Orphica contain brown corpuscles; and Will has concluded that the reddish threads found along the aquiferous canals of this animal, and which Ehrenberg (Abhandl. d. Berl. Akad. 1836, p. 198, Taf. VI. fig. 3, 3, and Müller's Arch. 1834, p. 568) has taken for striated muscles, are really blood-vessels. Profound researches must decide the real relation of the aquiferous canals to the sanguineous system filled with a violet liquid of Pceis, as described by Costa (Ann. d. Sc. Nat. XVI. p. 188, Pl. XIII. fig. 3). It should be mentioned that the blood-system of the Acalephae, which Will has described with so much positiveness, is not verified either by Bergmann or Frey and Leuckart (Beitr. p. 38), after numerous special researches.

2 If, and especially with the Discophora, these canals have been taken for digestive tubes, it is because faces and particles of food have been here found, and which have been ejected through the openings on the borders of the body. But the real function of these openings is to discharge the water unit for respiration; and it is only during the ingestion of this liquid that these foreign particles are thus introduced. This communication between the respiratory and digestive systems reminds one of the Polyps, where (as in the Anthozoa) the openings in the stomach allow its contents to pass into the cavity of the body, which last may be likened to the aquiferous system. On the other hand, the opinion that these canals are blood-vessels would be supported by the Ctenophora, since here they are filled with a red liquid, but, according to Will (Hermes tertius. p. 34), this liquid is not in these canals, but in proper blood-vessels surrounding them. Hence also, that these blood-vessels of the Ctenophora open upon the surface of the body, or that the blood escapes outward mixed with fæces.
§ 64.

With the Ctenophora, this respiratory system consists of an infundibuliform cavity, communicating with the stomach by two orifices, situated at its base and surrounded by sphincters.

Numerous aquiferous canals pass out of this cavity, traverse the body in a longitudinal direction, and finally anastomose with an annular vessel surrounding the mouth; but, beside these, there are two short canals which pass directly to the posterior extremity of the body, where they open externally.

With Eucharis and Cydippe, these canals are differently distributed; thus, two go to the tentacles, two to the sides of the stomach, and four to the sides of the body. The same is true with Beroe, excepting that those to the tentacles are wanting. The lateral canals divide, at a short distance from the cavity, into as many branches as there are sides. With Cydippe, the excretory canals are simple; with Eucharis they are provided with vibratile lamellae, and with Beroe with branching appendages. 1)

With the Discophora, numerous aquiferous canals pass from the stomach or its appendages, traverse the disc in a radiating manner, sometimes bifurcating, and terminate at the borders of the disc in an annular vessel which opens externally by numerous orifices.

In Cystaeis, Geriyonia and Thaumantias, there are four of these canals, arranged in a crucial manner; 2) and in Aequarea there are seventy-four disposal in a ray-like way. 3)

In Medusa aurita, there pass from the four folds of the stomach sixteen of these canals, eight of which are simple, and eight bifurcating numerously before reaching the marginal vessel of the disc. 4) With Stenonita and Aurelia 5) they are very numerous and widely branched.

With Medusa aurita, the terminal openings of the annular vessel are eight, and regularly alternate with the organs of hearing there situated. 6)

But in Cephea these openings are said to be directly beneath these last-named organs. 7)

With the Siphonophora, an aqueous system has not yet been well made out. There is, however, with some, an elongated cavity which is perhaps respiratory, and which, in some species, opens into the stomach, and in others directly upon the outer surface. 8)

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1 Will (Horne tertest. p. 50, Taf. 1.) has made very minute researches upon the aqueous system of Eucharis, Cydippe and Beroe. That of Beroe aurata, Forskalii, and of Leucoria vitrea, has been carefully described and figured by Mine Edwards as a circulatory system (Ann. d. Sc. Nat. XIII. p. 329; XVI. p. 203, 213, Taf. III. VI.).

2 Will, loc. cit. Taf. II. fig. 5, 7, 8, 14, 16.


5 Eichdeuffcnitz, loc. cit. Taf. IV.; also Brandt, Mem. de l'Acad. d. Sc. de St. Petersburg. IV. 1838, Pl. IX. X. XI.

6 Ehrenberg, Muller's Arch. 1834, p. 569; also, Abbandoni, loc. cit. p. 188, Taf. I. fig. 1; w. and Taf. IV. fig. 2, s.

7 Will, loc. cit. p. 60.

8 In Phoinophore, this canal terminates in this way by an oval dilatation, lined with ciliated epithelium, and has perhaps properly been regarded by Will (loc. cit. p. 78, Taf. II. fig. 22, a.) as a respiratory organ. A similar cavity, with a canal appendage, is found in Erria (Will, loc. cit. p. 51, Taf. II. fig. 27-31, d. e.) If the arms provided with openings, of the Phoinophore, are really stomachs, then the cavity beneath them, which has a canal passing along the axis of the animal, should be taken as belonging to the aqueous system, for it receives water by an opening at the base of the anus. This same opening has been taken for a month by Philippus (Muller's Arch. 1845, p. 66, Taf. V. fig. 10). According to Lesson (Imper- rey, Voyage, loc. cit. No. 6, fig. B), there is between the suckers of Velella an orifice which leads from before backward into a large branching canal. This structure, hitherto regarded as a digestive
CHAPTER VIII.

ORGANS OF SECRETION.

§ 65.

The air-cavity of certain Siphonophora, which is surrounded by a double membrane, ought probably to be regarded as an organ of secretion; for, according to many naturalists, the air contained could not have been derived from without, and consequently was secreeted by the sides of the internal membrane.(1)

CHAPTER IX.

ORGANS OF GENERATION.

§ 66.

Reproduction by fissuration and gemmation with the Acalephae has been observed only in the youngest states of certain Medusae.(1) But reproduction by caviety, belongs probably to the aquiferous system. That which in Porpita has been taken for a mouth, belongs probably, also, to the same system. I would not, however, deny that another signification may be given to the so-called respiratory and digestive organs of the Siphonophora.

If one regards, with Philippi, to regard the openings between the tentacles of Physophora, Velella and Porpita, as a mouth, then the cavity of those tentacles should belong to the aquiferous system. Moreover, these tentacles, as to their form and mobility, recall one of the pedicels of the Echino-derms; but it is remarkable that they can absorb food.

Sars (Fauna litoral. Norveg. p. 34, 42, Tab. VI. fig. 3, e, and Tab. VII. fig. 3, e, c) has observed in the interior of the cartilaginous, nutatory pieces of the Physophoridae and Diphyidae, aquiferous canals which are probably of a respiratory nature. Hattard, likewise, regards the hollow and tubuliform tentacles of Velella as aquiferous tubes, and in this way, the tentacular feet of the Echino-derms, includes them in the aquiferous system. See Ann. d. Sc. Nat. III. 1846, p. 250.

1 Many naturalists entirely deny the presence of openings in these soral cavities, and do not admit that they are filled with gas. Thus Philippi (Muller’s Arch. 1845, p. 63) affirms to have found neither external opening nor air in the pouch at the end of the longitudinal canal of Physophora tetrasticha. Offer (Abhandl. d. Borch. Akad. 1831, p. 165) has not been able to find in Physatia the opening of the internal sac, said to be near the one of the external sac. In fact, Bennett (Proc. Zool. Soc. London, 1837, p. 43; and Wiegmann’s Arch. 1838, II. p. 332), with the same species, has not seen an opening of this cavity, and was unable to force air from it. Future researches must determine if these pouches have not a respiratory function.

In the same way, Will (Flora litor. p. 42) has seen analogous bodies detached from Escharis, and has found in the water others supposed to belong to the Ctenophora, but has not traced their further condition. Propagation by buds has also been found with the Acalephus, through the excellent researches of Sars (Fauna litoral. Norveg. p. 31, Tab. IV. fig. 3-12), for this observer has seen on the external surface of the tubuliform stomach of Cynea octa- punctata, and upon the four ovaries of Themmnias multicentralis, small ctenophoral Acalephs resembling their parent, in the process of development, and which were finally detached. In the genus Acanthomedus which is allied to Agalma, Sars has observed (Ibid. p. 38, Tab. VI. fig. 14-17) ctenophoral bodies sprout out between the pre-hindle filaments and the tubuliform stomach, and which were finally detached, swimming freely like the Discophora. According to Sars, also, (Ibid. p. 43, Tab. VII. fig. 11, b. 13, b. and 14), there is, likewise, an analogous mode of propagation with Diphyidae.(2)

* [§ 66, note 1.] See also Huxley (Ann. Nat. Hist. VI. p. 594), who has described the reproductive processes of the Diphyidae, and shown that they multiply by gemmation as well as by ova. See also, Muller’s Arch. 1851, p. 320, Taf. XVII.
duction by eggs, and consequently by the means of proper genital organs, has been observed in all the families.

With the Ctenophora, (3) both sexes are combined in the same individual; but with the Discophora, the individuals are of one sex alone. (2)

§ 67.

The eggs are spherical, ... surrounded by an exceedingly thin envelope. The vitellus is of a whitish violet or yellow color, and contains a germinative vesicle, and germinative dot. (3)

The spermatic particles, which have generally the form of Cercaria (that is, a head and a filiform tail), are very active, and suffer no change in water. (3)

In some Siphonophora, they appear to have a linear form, and attain a very great size. (2)

§ 68.

The genital organs are not developed except at the epoch of procreation, and this period is very brief. On this account, their existence has often escaped the notice of observers.

The male and female organs so closely resemble each other, as to color, form and position, that they are easily confounded. They consist either of elongated pouches, or of ribbon-like bands, which are situated in different parts of the body. In the first case, the sperm and eggs escape through particular excretory canals; in the second, they escape directly forwards from the ovaries or testicles, or pass first through large cavities which communicate externally.

As they have no copulatory organs, the water is the medium of fecundation. In this way the unaffected spermatic particles are brought in direct contact with the eggs.

2 Will, Fritschi's neue Not. No. 559, p. 66.
3 Siebold, Fritschi's neue Not. No. 1091, 1856, p. 32.

Wagner (Prodrom. loc. cit. Taf. I. fig. 2; and Ann. zoolog. Tab. XXXIII. fig. 18-17) and Siebold (Beitrage zur Naturgesch. wirbelloser Thiere. loc. cit. Taf. I. fig. A. B.) have figured the eggs of Cyanea pelagica, and of a Medusa.

2 The spermatic particles of Eucharis and Ber-rar consist of a round body, having a delicate and very movable tail (Will, loc. cit. Taf. I. figs. 6, 24). In Cydippe they are similar (Krohn, Fritschi's neue Not. No. 355, 1841, p. 52). This is likewise true of those of the Discophora; see Siebold, Beiträge loc. cit. Taf. I. fig. c. (Medusa); Kölliker, Beiträge loc. cit. Taf. I. fig. 8, 9, 10; and Milne Edwards, Ann. d. Sc. Nat. XVI. Pl. I. fig. 1, d. (Rhizostomum, Chrysaora and Aeugorea);

3 [§ 66, note 3.] Reproduction by fissuration has been observed in the Discophora by Kölliker (Siebold and Kölliker's Zeitsch. IV. p. 325); he witnessed this phenomenon with Stomobrachium mirabile. It does not appear, however, that he has observed this process with adult forms; for he remarks that there is reason to believe that this Stomobrachium is only a young, imperfect form of his Mesoneura eoceruslens. — Ed.

† [§ 67, note 2.] The spermatic particles of the Acalephae have invariably, I think, a cercaria-like form, like those of the Polyps, and like which, also, they are developed in special daughter-cells. — Ed.

‡ [§ 67, note 5.] These bodies mentioned by Will as spermatic particles have since been examined by Huxley (loc. cit.), who thinks they are not of this nature, a view which is otherwise probable from the fact that he found no male generative sacs, and also because, as I have shown (see my note after § 64, note 5), these particles with Aegynella have a cercaria-form. — Ed.
§ 69. THE ACALEPHAE. 71

§ 69.

The position of the sexual organs varies in the different orders, in the following manner:

1. With the Ctenophora, which are hermaphrodites, they are situated along the sides, under the form of elongated utricles, the testicles being on one side and the ovaries on the other. They have a nodulated appearance, and from the lower part of each pass off an excretory duct, which runs toward the mouth, but the terminal opening of which has not yet been well made out. (6)

2. With many Discophora, these organs are arranged like rays, passing from the centre to the border of the disc. In Oceania, Cystaeis, Geryonia and Thaumantias, the four saccular ovaries or testicles form at the centre of the disc a cross, which is traversed by four aquiferous canals. Their excretory ducts pass towards the base of the stomach, but their terminal openings are not distinct. (3)

In the disc of Aequorea violacea, seventy-four ray-like bands are spread out, and the free plicated borders of these hang beneath the inferior surface of the disc, thus permitting the free escape of the eggs and sperm into the water. (4)

3. Another group of the Discophora have at the base of their tentacles four large openings, which lead into as many cavities in the disc. (5) At the base of these cavities, which formerly were regarded as respiratory organs, the genital organs are situated in the form of plicated bands. These as four bands (testicles or ovaries) are bent either into an angle or the are of a circle, forming sometimes a star with four rays, (6) and sometimes a four-lobed rosette. (7) If these cavities increase in number, the genital organs increase in the same proportion. (9) The border of these organs is generally provided with numerous tentacles which project into the cavity. (9) In the ribbon-like testicles numerous small sacs are observed; each one of these opens separately into the genital cavity, while the eggs, on the contrary, are separated from the similarly-formed ovary only by a gradual constriction of the latter. (10)

4. With the Cephalophora, all the relations of these genital organs still require much investigation. With the Diphyidae, they consist of sacs communicating with the general cavity of the body. (11) During the epoch

1 Will, Horae tergest. p. 38, Tab. I. fig. 22, 23.
2 Wagner, Icones zool. Tab. XXXIII. fig. 26, a. a.; Will, loc. cit. Tab. II. fig. 5, 7, 8, 14, 16; Blainville, Manuel d'Artzol. loc. cit. Taf. XXXVII. fig. 3; and Sars, Beschriiber loc. cit. Taf. 12, 13.
3 Will, loc. cit. p. 71.
5 Goede, Beiträge loc. cit. Tab. I. fig. 1, c. (Medusa); and Lessou in Duperrey, Voyage loc. cit. No. 12, 13 (Chrysea).
6 Rhizostoma.
7 Chrysea, Medusa, Pelagia and Aurelia. See Ehrenberg, Abhandl. d. Berl. Akad. 1855, Tab. I. fig. 1; Wagner, Icon. zool. Tab. XXXIII. fig. 1; and Brandt, Mem. de l'Acad. de St. Petersburg, IV. Pl. IX. X. With the male and the female Cephea, I have found the testicles and the ovaries disposed exactly as with the Medusa. (7)
8 In Cassiopea, these organs are so numerous.
9 Medusa and Pelagia; see Ehrenberg, loc. cit. Taf. VII.; and Wagner, Icon. zool. Tab. XXXIII. fig. 13.
10 Siebold, Beiträge loc. cit. Taf. I. fig. 20, 23; and Kallger, Beiträge loc. cit. p. 40.
11 In Diphyes and Erassore, a sac filled with cells opens into the general cavity of the body, and communicates beside with the stomach and respiratory cavities. Will (Horae tergest. p. 78, 81, Tab. II. fig. 21, c.) regards this sac as a sexual organ; and Meyen (Nov. Act. physico-med. XVI. Suppl. 1, 1834, p. 214, Tab. XXXVI. fig. 2, h. and fig. 6, 7) asserts to have seen eggs in it. According to Philippo (Maier's Arch. 1843, p. 63, Taf. V. fig. 10, a, b.), the grape-like clustered genital organs, with Physophora, are situated between the prehensile organs; the smallest containing in each lobule six to ten eggs, and the largest a granular liquid (Sperm?).
12 Hallock (Ann. d. Sc. Nat. III. 1846, p. 113, IV. bis. fig. 23, 34) has found both testicles and ovaries as described on the tubulariform tentacles (stomach).
of procreation, the females of some Discophora are easily distinguished from the males by the numerous pouches of their tentacles, and in which eggs and newly-hatched young are carried for a short time.\(^{[2]}\)

§ 70.

As yet, the development of a few only of the Acalephae has been traced. It is attended by a remarkable metamorphosis.

After the usual segmentation of the vitellus, ovoid embryos resembling infusoria are developed; these turn freely on their axis, and swim about in the water by means of ciliated epithelium.\(^{[1]}\) Shortly after, they become attached by the anterior extremity to some object. Upon the opposite free extremity tentacles appear, and between them the mouth. The animal has then the form of a Polyp.\(^{[3]}\) It is during this period that the young animal reproduces by gemmation,\(^{[4]}\) and sometimes by transverse fissuration. This last mode occurs in the following remarkable manner:

The polyp-like animal increases in length, and its body divides transversely into many segments. Around each of these segments eight bifid processes are developed; after this, each segment is successively separated from before to behind, and they float about for a time as eight-rayed Acalephae, but soon attain, however, their adult condition.\(^{[5]}\)

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\[^{[1]}\] Sars (Isis. 1833, p. 222, Taf. X. fig. 2).\n
\[^{[2]}\] Froriep’s Abhandl. p. 166, 1837, has regarded these young Medusae, whilst composed of rings, have been taken for a new genus (Scephiostoma) of Polyps by Sars (Isis. 1833, p. 224, Taf. X. fig. 4; and Baer) and Froriep (ib. p. 16, Pl. II.) has described them as a new species of Medusae (Strobila octomandata). But lately he has perceived that they are the young of Medusa aurita (Wiegmann’s Arch. 1837, p. 490); and did not occur to him, however, that these young constitute, very probably, the genus Ephyrus of Baer (ib. p. 16, Pl. II.). Therefore it is very likely that they all undergo a similar metamorphosis. It may also prove that many naked Polyps are only transitional forms of known species of Acalephae. In this connection the observation of Dujardin (Compt. rend. 1845, p. 1132) deserves the attention of naturalists. In tracing the development of one of the Discophora allied to Oceanina, he observed that this animal in its early condition separated from a coelentera resembling that of Synkarya, and was of a form quite like an Eilethynia. However various these developing forms may be, that one must be regarded as the real one which exists during the development of the tentacles and ovaries.*

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* See also, for recent researches on the development of Cephea, Ecker, Bericht üb. die Verhandl. d. naturf. Gesellsch. in Basel VIII. 1849, p. 51; Busch, Beobachtungen üb. die Anat. &c. Berlin, 1851, p. 50; and Frank, in Siebold und Kolliker’s Zeitsh. f. Zool. IV. p. 118, June, 1852. --- Ed.

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\[^{[1]}\] Sars (Isis. 1833, p. 224, Taf. X. fig. 4; and Baer)

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\[^{[3]}\] Siebold, Beitrage loc. cit. p. 29, Taf. I. fig. 25-33, Taf. II. fig. 34; and Sars, Wiegmann’s Arch. loc. cit. Taf. I. fig. 7-31. During my last visit at Trieste (autumn of 1847), I convinced myself that the young of Cephea Wagneri are developed wholly like those of Medusae, by passing from infusoria-like forms to polyoid young animals.*

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\[^{[4]}\] The reproduction of the polyp-form Medusae, by buds has been observed by Sars in Cypna capillata. He has also seen them develop pedi-
of the hypotheses suggested in the above note. Hitherto there has been much confusion on this subject, from the want of complete series of observations; even now the whole class can be regarded only in a somewhat transitional state, in a zoological point of view. Many genera which have hitherto been regarded good and permanent will no doubt, as Siebold has remarked, prove to be only undeveloped forms of well-known species. As already stated, Agassiz regards the Hydroid Polypi as true Acalephae, and the analogy which exists between the embryos of Medusae and Polypi may be the foundation of many other important changes. At present, however, broad generalizations must be deferred until we have extensive and serial researches in the embryology of these animals. For separate details on the development of some forms, see Busch, loc. cit. (Sarsia, Lizia, Cephea, Eudsonia, Diphyes); Huxley, loc. cit. (Diphyidae, Physophoridae); Agassiz and Desor, loc. cit. (Metasidae). — Ed.
BOOK FOURTH.

ECHINODERMATA.

CLASSIFICATION.

§ 71.

The Echinoderms have a more or less coriaceous envelope, filled with calcareous, reticulated corpuscles. These last are sometimes so numerous that they form a real shell, composed of plates, movable, or tightly bound together. In the ray-like, symmetrically-arranged systems of organs, the quinquenary number prevails.

In many species the digestive canal is asymmetrical. All are marine, and most of them move by means of particular, erectile suckers. Others progress by vermiform motions, and some swim freely by moving their rays like oars. Only a few are stationary. All are without copulatory organs.

ORDER I. CRINOIDEA.

The calcareous shell, composed of movable pieces, forms a true cutaneous skeleton. The body is ray-like; the digestive canal, asymmetrical.

Family: Encrinidae.
Genus: Pentacerinus.

Family: Comatulinae.
Genus: Comatula.

ORDER II. ASTEROIDEA.

The calcareous shell, composed of movable pieces, forms an internal skeleton. The cutaneous covering is sometimes coriaceous, and sometimes calcareous. The body is ray-like, and the digestive canal symmetrical.

Family: Ophiuridae.
Genera: Astrophyton, Ophionyx, Ophiothrix, Ophiomastix, Ophiocoma, Ophioplepis, Ophioderma.
§ 71. THE ECHINODERMATA.

Family: Asteroidae.


ORDER III. ECHINOIDEA.

The calcareous shell forms a spherical or discoid shield, composed of inmovable plates. The digestive canal is asymmetrical.

Family: Echinidae.

Genera: Echinus, Cidaris.

Family: Clypeastridae.

Genera: Laganum, Scutella, Encope, Rotula, Lobophora, Echinocyamus, Mellita, Echinanthus.

Family: Spatangidae.

Genus: Spatangus.

ORDER IV. HOLOTHURIOIDEA.

In place of a calcareous shell, the cutaneous envelope contains a greater or less number of calcareous reticulated corpuscles. The oesophagus is surrounded by a calcareous ring, constituting the rudiment of an internal skeleton. The body is cylindrical. The digestive canal, generally asymmetrical.

Family: Holothurinae.

Genera: Holothuria, Pentacta, Bohadschia, Cladolabes.

Family: Synaptinae.

Genera: Synapta, Chirodota.

ORDER V. SIPUNCULOIDEA.

The cutaneous envelope is coriaceous, and free from calcareous corpuscles. There is no calcareous ring about the oesophagus. The body is cylindrical; the digestive canal, usually asymmetrical.

Family: Sipunculidae.

Genera: Sipunculus, Phascolosoma.

Family: Echiuridae.

Genera: Thalassema, Echiurus.
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Ueber die Larven und die Metamorphose der Echinodermen, vierte Abhandlung. Read to the Berlin Acad. 7, Nov. 1850; 28 April and 10 Nov. 1851, and published in 1852.


These writings relate chiefly to development; but, for many special points of Anatomy, see the writings of Müller, Krohn, Peters, and others referred to in my notes. — Ed.

CHAPTER I.

CUTANEOUS ENVELOPE AND SKELETON.

§ 72.

With the exception of the apodal Sipunculidae, the Echinoderms have a cutaneous skeleton modified in the different orders in the following manner:
§ 72. THE ECHINODERMATA.

I. In the Holothurioidea, irregular calcareous corpuscles, which often have reticulated openings, are scattered through the skin. (1)

II. In the Echinoida, the calcareous substance is separated from the soft skin, and composed of plates of a definite form, pierced by openings. These plates are immovably united together by means of sutures. These last are easily seen in the Echinidae, but are indistinct in the Clypeasteridae; they entirely disappear with age in some species. (2) Among these plates which are arranged in a regular series, those called ambulacral should be mentioned; these are perforated, having upon their outer surface the pedicles, and upon their inner the ambulacral vesicles. They form, usually, five double rows, so placed between the other plates that their openings form, sometimes five longitudinal rows extending from the mouth to the arm, (3) sometimes a rosette of five lobes (4) on the dorsal surface of the skeleton. (5)

III. The coriaceous skin of the Asteroida, like that of the Holothurioidea, contains numerous calcareous corpuscles, of which the smallest are irregular, the largest porous. But beneath this is a cutaneous skeleton, composed of porous calcareous pieces, movably articulated, and extending on the ventral surface from the mouth to the end of the rays.

In many species, the larger corpuscles, pressed together, form a reticulated support, which is either simple (6) or composed of plates. (7)

With the internal skeleton, each articulation is usually composed of many pieces, the intervening lacunae of which are the ambulacral pores. The principal middle pieces unite at an obtuse angle, thus forming an abdominal furrow. (8) The Ophiuridae have also an articulated internal skeleton, but the articulations are simple. But the external envelope of their arms consists of calcareous scales, closely knit together, and which so tightly close up the internal skeleton that the cavity of the body does not extend between the skin and the internal skeleton into these appendages, as in the Asteroida.

IV. In the Crinoidea, the skin is soft only on the ventral surface; that of the back is wholly calcareous, and converted into an articulated skeleton, which extends upon the arms and lateral branches. The mobility of these articulations is due to an elastic, interarticular tissue. They constitute discs or short cylinders, which, joined together, form arms, lateral branches (pinnae), cirri, and in some species a poduncle. (9)

There is a canal in axis of all these parts of the skeleton, and upon the

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1 These irregular and usually perforated calcareous corpuscles are mixed with the sand of the sea, after the death and decomposition of the animal, but can then easily be distinguished with the microscope. Quatrefages (Ann. d. Sc. Nat. XV. 1842, Pl. III. IV.) has figured many of them belonging to Synaptia. Similar microscopic corporcles, of various forms, are found in the soft parts of most of the Echinoderms. It is very desirable that, as has already been commenced by Ehrenberg (Abhandl. d. Berl. Akad. 1841, p. 498), they should be subjected to careful investigation; for by this way alone can correct views be obtained upon many enigmatical bodies of this kind seen by the naturalist.

2 Scutella and Clypeaster.

3 Echinus and Cidarion.

4 Encope, Rotula, Scutella, &c.

5 A very detailed description of the shell of Echinus will be found in Meckel's System der vergleich. Anat. II. Abh. 1, 1834, p. 31; and in the monograph of Valentin, Anat. du genre Echinus, 1841, p. 5. He has also published very exact researches, with figures, upon the intimate structure of the calcareous plates of this animal (Ibid. p. 17, Pl. II.).

6 Asteracanthion, Solaster.

7 Asteracanthion, Scyaster, Solaster, &c.

8 See the figure by Sharp, Cyclop. Anat. and Phys. loc. cit. p. 31, fig. 8, 9; and Meckel's vergleich. Anat. II. Abh. 1, p. 19.

9 Pentaceraster.
ventral surface of the arms and pinnulae, a furrow, over which the soft skin (perisoma) passes in a bridge-like manner.\(^{10}\)

§ 73.

In many Echinoidae the buccal cavity is provided with processes pointing perpendicularly into the interior of the shell, and which are the points of attachment of the masticatory muscles and ligaments. This osseous circle is most developed in the Echinidae,\(^3\) and is composed of five processes. Between each of these is a smaller one, corresponding to as many ambulacral ones, each of which is perforated by a large opening.\(^3\) In the Olypeastridae, there are five simple processes only;\(^3\) and in the Spatangidae they are wholly absent.

The sub-cutaneous osseous ring about the oesophagus, in the Holothuroidea, corresponds probably to this circle. Usually composed of ten pieces, it may be regarded as a rudimentary internal skeleton, for it is the point of attachment of both muscles and tentacles.

In Holothuria tubulosa its anterior border is denticulated;\(^{10}\) and in Synapta it is composed of twelve pieces, five of which have oval openings for the free passage of the afferent canals.\(^3\)

§ 74.

The general envelope of many Asteroidea is more or less covered with various calcareous productions. These have the forms of lamellae, knobs, callosities, granules, immovable rays both sharp and blunt, rough and smooth movable points, double hooks, \&c.\(^{10}\)

In the Echinidea, there are points of very variable size united to knobs which are scattered over the external surface of the shell. These points project through the thin skin covering this shell, having at their base a kind of capsular articulation.\(^3\)

Remarkable cutaneous organs are found in Synapta. These are small anchor-like hooks, by which these animals attach themselves to objects. Each of them is obliquely inserted under a small sub-cutaneous scale, which is perforated by a canal.\(^{10}\)

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\(^{10}\) In the Crinoidea, as well as in the Echinodermata generally, the parts of the skeleton have a calcareous, reticulated structure; see Müller's Arch. 1817, p. 24, and Uster d. Raut. d. Paleontol. caput Medusaese, in the Abhandl. d. Berlin. Acad. 1817, Taf. 1, fig. 3.

1 Echinosus, Cebetam.

2 Valentin, Monogr. loc. cit. PI. II. fig. 15.

3 Agassiz, Monogr. d'Echinodermes, 2d ed., containing the Scutellae, PI. XIII. fig. 3, PI. XXVII. fig. 7 (Lobophora and Echinoecanium).

4 Wielemann, Ann. d. Königsth. Palais, lib. 29, Tab. II. fig. 5; also Wagner, loc. cit. Tab. XXVII. fig. 18.

Koren has observed that the ossosseous ring is composed of ten pieces with Thyone fusca and Cystidea spinosa of the Holothuriada.

5 Quatrefages, Ann. d. Sc. Nat. XVII. 1842, p. 47, PI. IV. fig. 5; PI. V. fig. 7, c. c.

1 With Ocreaster and Cucubia, the whole body is covered with knobs and granulations. With Astrocopus and Stellaster, you find flattened knobs and marginal lamellae. Immovable rays, with beaded points, project from the surface of So- lapse and Chactaster. With Ophiocoma and Echinolamprus, the margins of the arms are covered with smooth points, which in Ophurothrix are spines. In Ophiopyx these spineous points have movable double hooks; see the beautiful figures of Müller and Troschel (Systema d. Anim. 1842).

2 The spines of the Echinidea have, over their whole extent, numerous, denticulated ribs; see Valentin, Monogr. loc. cit. PI. III. fig. 25. In Synapta there the spines are spatulate, and in the Olypeastridae (Millelia, Encope, Lagamum) they are ciliate. The minute researches of Valentin (Monogr. loc. cit. p. 21, PI. III) have shown the structure of the spines of the Echinidea to be very complex.

3 The hard-like roughness of the skin of Synapta has already been observed by Eschholz (Zool. Atlas, Hist. 2, 1823, p. 12). Jaeger (De Holothuriis dissertatio, 1843, Tab. I, fig. 2) has figured the cutaneous hooks of Synapta Benelli. Quatrefages (Ann. d. Sc. Nat. XVII. p. 25, PI. III) has given a very exact description of those of Synapta
§ 75. A peculiar calcareous plate (the madreporic plate) is observed upon the cutaneous skeleton of the Asteroidae and Echinoidea. In the last it is always situated in the centre of the dorsal surface, but in the first its position varies. In the proper Asteroidae there are often several, having an excentric dorsal situation; while in the Ophiuridae it is found upon the ventral surface, and especially in the angle formed by the junction of the two arms with the tortuous mouth. In some Asteroidae a membranous sac (stony canal), filled with organized calcareous particles, is attached to this plate; in others, an articulated calcareous cord stretches obliquely across the body towards the border of the mouth. The use of these parts is not yet positively known. (2)

CHAPTER II.

MUSCULAR SYSTEM AND ORGANS OF LOCOMOTION.

§ 76. In the Echinoderms the muscular system is well developed. Its primitive fibres are flat, and without transverse stripe. (3)

In the ventral surface, and between each joint of the arms and pinulae of the Crinoidea, there are one or two small muscles, antagonistic to which, upon the opposite surface, is an interarticular elastic tissue. (3)

In the Asteroidae, the interarticular lacunae of the internal skeleton are filled with muscles. (3) The skin of these animals does not aid the motions of the arms, except by its elasticity. But in the Echinidae the skin

Duxeranae. The similar books found in the sea-bed of Vera Cruz have been taken by Ehrenberg for stony concretions belonging to a sponge, and figured and named Spongolitha anchora (Abh. d. Berl. Akad. 1841, p. 523, Taf. III, No. VII, fig. 36). He has also taken the perforated supports of these books for an infusion with a siliceous carapace, described as Dietyocha splendens (Ibid. fig. 35). But, more lately, he has perceived their true nature (Ibid. p. 407, 445).

The discovery of analogous cutaneous organs in the maid near Stredberg, by Count Munster (Betr. d. Peterf. Hfl. VI. 1843, p. 92, 96, Taf. IV, fig. 9), is very interesting, since it shows the antediluvian existence of Synapta.

Beside the cutaneous carcasses of carbonate of lime, Synaptae (loc. cit. p. 36, Pl. 111, fig. 13) has found others which are of a spherical form in the skin of Synapta Duxeranae; and, as they have protractile filaments, he compares them to osseous organs.

1 Astrophyton.
2 These parts are found in Astrophyton. According to Fleischer (loc. cit. p. 54), they furnish the necessary calcareous matter for the skeleton of the Astroidea. But Ehrenberg (Müller's Arch. 1834, p. 556) has shown that they do not contain ordinary calcareous matter, but rather that which is organized and perforated in a reticulated manner. A calcareous cord of a special structure is found in Asteracanthion; see Siebold, Müller's Arch. 1836, p. 291, Taf. X. fig. 14-18; and Sharpey, Cyclopaust. &c. loc. cit. II. p. 53, fig. 12, 13, &c. (1)

4 According to Warner (Müller's Arch. 1835, p. 319), the Echinoderms do not have transversely striated muscles. This has been confirmed by Müller (Abh. d. Berl. Akad. loc. cit. p. 214, Taf. IV, fig. 9) in the genera Pentacrinus and Comatula. For my own part, I have failed to perceive them in Echinus, Asterias, Ophiura, Holothuria, and Scyphocanthus. Valentin (Monogr. loc. cit. p. 101, Pl. VIII, fig. 153-155) asserts to have seen striae upon the fibres of the musculatory, spinous and anal muscles of Echinus; and Quatrefages (Ann. de Sc. Nat. loc. cit. p. 43, Pl. 111, fig. 17) has observed transverse wrinkles during the contraction of the longitudinal muscles of Synapta. (2)


3 The interarticular muscular layer of the Asteridea has been accurately described by Meeckel (System d. vergleich. Anat. 111. p. 14).

1 [§ 75, note 2] See, for further details on this stone-canal with the Ophiuridae, Müller, Arch. 1850, p. 122. — Ed.
covering the shell has distinct muscular bands for the motions of the points.\(^4\)

In the Holothuroidea and Sipunculoidea there is a very thick subcutaneous muscular layer. This is itself composed of two layers,—the first and upper being made up of circular, the second and lower of longitudinal fibres. In the Holothuroidea,\(^3\) these fibres form five large, thick, widely-spread bundles, which are inserted into the osseous ring. In the Sipunculoidea, these bundles are more numerous, but more compactly bound together.\(^6\)

The muscles of mastication, of the digestive canal, and of the tentacles, will be treated hereafter.

\section{§ 77.}

With the exception of the Synaptinae and Sipunculoidea, the Echinoderms have special, tentacular, locomotive organs (ambulacra). These are hollow and very contractile prolongations of the skin, and communicate through the ambulacral pores with small contractile sacs (ambulacral vesicles), found upon the internal surface of the coriaceous or calcareous envelope of the body. The ambulacra and their vesicles have transverse, longitudinal fibres, and contain a clear liquid, which, from contractions, oscillates from one to the other through the pores. In this way the ambulacra are capable of erection and elongation, and the animal uses them as feelers to find a proper object of attachment; and on this account, also, they have in some species a suckorial extremity.

These organs, which are sometimes locomotive, sometimes prehensile, have the following variations of structure and form:

I. With the Crinoidea they are small, delicate and cylindrical, and are found upon the borders of a furrow, which runs from the mouth along the soft perisoma covering the arms and pinnulae. Each one of them is covered with small cylindrical, clavate tentacles.\(^3\)

II. The Ophiuridae have upon their arms, and between the plates, pores which connect with small cylindrical ambulacra; these last, from numerous smallwants, present a studded aspect.\(^2\)

III. With the Asteroidea they are situated in a double or quadraple row, in the ventral furrows which extend from the mouth to the end of the rays. They form compact cylinders of considerable size, the acute or truncated extremity of each of which has a sucker.\(^3\)

IV. With the Echinoida they are situated upon an elongated stalk, and have a sucker. They are found both upon the ambulacral plates and immediately around the mouth.\(^1\) Being extremely movable, they are

\(^4\) Valentin, Monogr. loc. cit. p. 33, Pl. III. fig. 33.

\(^5\) The cutaneous muscular system of Holothuria has been described by Tiedemann (loc. cit. p. 27, Tab. II. IV.); and that of Synapta by Quatrefages (Ann. d. Sci Nat. loc. cit. p. 41).

\(^6\) For the muscular system of Sipunculus nudus, see Grube, in Müller's Arch. 1857, p. 240, Tab. XII. fig. 1.

\(^1\) The ambulacra of Comatula, which have active vermicular movements, have no opening at their free extremity; see Müller, Abhandl. d. Berl. Akad. loc. cit. p. 222, Tab. IV. fig. 13, 14.

\(^2\) By these the very active arms of the Ophiuridae are attached to surrounding objects; see Erdl in Wiegmann's Arch. 1842, I. p. 55, Tab. II. fig. 1, a.

\(^3\) Beside the very correct description given of these organs by Tiedemann (loc. cit. p. 50), see Ryder Jones (A Gen. Outl. of the Anim. King. p. 115, fig. 65). It appears that in Astropocephal the extremity of the ambulacra can be inverted, thus compensating for the sucker found in Echinaster, Asteriscus, and Asteroacanthion.

\(^4\) With Echinus the suckers, which exactly resemble the other ambulacra, are fixed upon the contractile membranes surrounding the mouth. With Spatangus and Echinometra there is
§ 78. THE ECHINODERMATA. 81

chiefly locomotive; for from them numerous points are prolonged, by which they adhere to objects, and to which they become afterwards fixed by their sucker. They are covered with ciliated epithelium, and their suckers are made firm by a coarse calcareous network. Elongated calcareous corpuscles of the same nature are found also in their walls,—some branching and others hook-like.\(^{2}\)

V. With those Holothurioidea which have them, they have a more or less complete sucker, and are scattered irregularly over the entire surface of the body, or disposed in regular rows. Usually very short, they can be retracted deeply in the skin; but they are capable of equal prolongation, and thus perform well the function of suckers.\(^{3}\)

The ambulacral vesicles, which are intimately connected with the circulatory and respiratory systems, will be fully treated hereafter.

§ 78.

With the Echinoidea, and Asteroidae, there are other movable organs (pedicellariae), which, scattered over the surface of the body, are prehensile, and used in a pincer-like manner. With the Asteroidae, they usually consist of two delicate forceps-like pieces (pedicellariae forcipatae), or of two large valvular flaps (pedicellariae valvulatae). Generally they are not pediculated.\(^{4}\) Those of the Echinoidea have been carefully studied in *Echinus*. They are numerous, and occur for the most part about the mouth, presenting three different forms: 1. Those composed of three short, lenticular pieces (pedicellariae gemmiformes). 2. Those formed of three long delicate pieces, laterally denticulated (pedicellariae tridaetyle). 3. Those with three laterally denticulated spoon-like pieces (pedicellariae ophiocerphi). They are supported by a base of calcareous, reticulated substance; and in the Echinoidea, always rest upon a stalk, the lower part of which contains a cylindrical, calcareous nucleus, while the remaining portion is soft, and capable of a spiral contraction.\(^{5}\) Here also they are covered with ciliated epithelium, and can, by means of movable processes, seize hold of objects, which, being passed along, may be conveyed even from the dorsal surface to the mouth.

near the mouth, and opposite the ambulacral rosette, a row of ambulacra having special pores.

3 See *Valentin*, Monogr. loc. cit. p. 37, Pl. IV. V., and *Erdt* in *Wiegmann's Arch.* 1842, I. p. 55, *Taf.* H. fig. 10. The corpuscles found by *Ehrenberg* (Abhandl. d. Berl. Akad. 1841, p. 324, *Taf.* III. No. VII. fig. 37, a. b.) in the marine sand of Vera Cruz, and figured under the name of *Spongolithis uncinata*, are only the cruciform parts of the skeleton of *Echinus*. This will be evident from comparing them with the calcareous corpuscles figured by *Valentin* (Monogr. loc. cit. Pl. V. fig. 65).


5 With *Spatangia*, there are, however, three tongue-like pedicellariae. In *Asteroidea*, they have a soft pedicle. In *Astrogaster*, *Stellaster*, and *Astrogonium*, they are valvular and without a pedicle; see *Muller* and *Troschel*, loc. cit. p. 10, *Taf.* VI. fig. 3-5.

6 *Berl.* 1841, p. 324, *Taf.* VI. fig. 3-5.

*§ 78, note 2*] See *Adams* (Ann. of Nat. Hist. VIII. 1551, p. 257), who has found what he regards as Pedicellariae on the skin of *Volutes* vespertilia; he thinks, therefore, that they are independent parasitic organisms.—Ed.
CHAPTER III.

NERVOUS SYSTEM.

§ 79.

The central portion of the nervous system consists of a ring which is usually pentagonal, and surrounds the commencement of the oesophagus. The main nervous branches are given off from this, and pass to the other end of the body along the median line of the rays, or their corresponding parts. The form of this ring is mainly due to that of the mouth; and therefore, with the reniform mouth of Spatangus, it is unequally pentagonal.1) Ganglia have not yet been found in it. But in Echinus and Holothuria, the nerves passing from it have between their fibres, violet, green, or red pigment granules.2)

§ 80.

The principal nervous trunks have a longitudinal furrow, as if composed of double cords, and give off from each side, during their course, branches which go to the ambulacra.3)

With the Crinoidea, a nervous cord passes beneath the furrow formed by the perisona on the ventral surface of the arms; this has a slight swelling opposite each pinnula, to which it sends off a branch.4) With the Asteroidea, the nervous trunks which pass off from the oesophageal ring are lodged in the ventral furrows of the rays.5) But in the Ophiuridae, they pass in a canal, concealed by the ventral plates of the arms. The five nerves, analogous to those of the Echinoidea, pass along the internal surface of the ambulacral plates, between the vesicles, even to the centre of the dorsal region. In Echinus, there are, moreover, special nerves directly from the oesophageal ring, for the organs of mastication and digestive canal.6) In Holothuria, this ring is situated directly on the anterior border of the ossicle circle, and sends off five nerves which pass along the median line of the longitudinal muscles, even to the end of the body;7) it sends off also special nerves to the oral tentacles.8)

1 Krohn (Müller's Arch 1841, p. 8, Taf. I, fig. 3, 4).
2 Krohn, loc. cit.
3 Krohn, Ibid. p. 4, 10.
4 Müller (Abhandl. d. Berl. Akad. loc. cit. p. 233, Taf. IV, fig. 11, 4; Taf. V. fig. 10).
5 The nervous system of the Asteroidea was first clearly shown by Tiedemann (loc. cit. p. 62, Taf. IX. and Meckel's Deutsch. Archiv. L. 1815, p. 60, Taf. III. fig. 1). This anatomist, like Krohn (loc. cit. p. 4), did not perceive the ganglia of the oesophageal ring, observed by Wagner (Vergleich. Anat. 1834, p. 572).
6 The ganglia and nerves that Spix (Ann. du Mus. d'Hist. Nat. XIII. 1809, p. 139, Pl. XXXII. fig. 3, 6) and Konrad (De Asterolarium Fabricius desert. 1814, p. 13, fig. 3, 6) affirm to have seen on the internal (dorsal) surface, opposite the ventral

fallof the articular processes, in Asterocanthonium rubens, and glaciatus, are probably only tendinous fibres.

7 Krohn, who has studied the nervous system of Echinus and Spatangus, has traced the filaments given off from the main trunks, across the ambulacral pores, to the suckers of the ambulacra. See also Valentin's figures of this system, in Echinus (Monogr. loc. cit. p. 95, Pl. VIII. IX.),

8 The oesophageal ring of Holothuria, observed by Krohn (Müller's Arch. 1841, p. 9, Taf. I. fig. 5), sends off its principal nerves across the fissures of the dentations of the five great pieces of the ossicle rings. Their lateral filaments, going to the ambulacral vessels, are so fine that Krohn could scarcely find them.

9 Grant, loc. cit. p. 184.*

* [§ 80, note 6.] Muller has furnished some valuable contributions on the nervous system of the Holothuroidea; see Arch. 1850, p. 225. He makes this statement, which is worthy of remem-
§ 81. THE ECHINODERMATA

With the Sipunculidae, as with the other worm-like Echinoderms which approach the Annelids, the arrangement of the nervous system is quite different. Here, the nervous ring is a simple, aganglionic thread extending to the posterior end of the body, and may be regarded as the first trace of a ventral cord.\(^7\)

C H A P T E R IV.

ORGANS OF SENSE.

§ 81.

The sense of touch is well developed with the Echinoderms, and seems to have its seat in the oral tentacles, the ambulae, and pedicellariae.

With the Asteroidae, and Echinoidae, no organs of vision have yet been found. As such, however, have been regarded the red pigment dots situated, with the former, at the extremity of their rays,\(^1\) and with the latter, in the middle of the dorsal region upon five ocellary plates which alternate regularly with those of the genital organs.\(^2\) These ocellary plates are perforated each by a very fine canal, through which passes a delicate filament from the main nerve for the pigment dot.\(^3\) Although these pigment dots have thus a nervous connection, no proper organ to refract the light has yet been found in them.\(^4\)

\(^7\) According to Krohn (Müller’s Arch. 1839, p. 293), the oesophageal ring of Sipunculus nudus has two super-oesophageal ganglia blended together. These had already been observed by Deltechie (Monogr. loc. cit. 1. p. 13, Tar. 1. fig. 6. l.); but more lately Grube had taken them for cartilaginous rudiments of the ossous circle (Müller’s Arch. 1537, p. 244). He has also confounded with the muscular system the two lateral nerves of this ring, and its abdominal branch which in its course sends off laterally branches to the muscular layer and to the skin, and terminating at the end of the body in a swelling. Then, on the other hand, the filaments surrounding the digestive tube, and taken by him for nerves, appear to be only cellular fibres (loc. cit. p. 244, Tar. XI. fig. 4).

According to Forbes and Goodside (Frohribp’s note Not. No. 392, 1841, p. 279), the nervous system of Echiurus is composed of an oesophageal ring, with an abdominal cord, from which pass off asymmetrical branches. A few nerve fibres may besides be observed in the esophagus, but these are too feeble to observe with certainty (Monogr. loc. cit. p. 10, 106, Pl. II. fig. 12, Pl. IX. fig. 188, 189).

\(^1\) In the Clypeasteridae and Echinidae.

\(^2\) These dots, which Vahl (Müller Zool. Den. Tab. CXXXI.) had already observed in Pteraster militaris, were first regarded as eyes by Ehrenberg (Müller’s Arch. 1834, p. 571, and Abhand. d. Berl. Akad. 1835, p. 209, Tar. VIII. fig. 11, 13). He has seen in Asterometathion violaceus, a small swelling at the extremity of the nerve of the ocellary dot. Forbes (Hist. of the Brit. Star-fishes, 1841, p. 153) first noticed these dots in Echiurus, and their presence has been confirmed by Agassiz and Valentin (Monogr. loc. cit. p. 10, 106, Pl. II. fig. 12, Pl. IX. fig. 188, 189).

\(^3\) Valentin, loc. cit. Pl. IX. fig. 190.

\(^4\) Valentin has failed to discover in these organs a crystalline lens. Although in Echiurus they are upon the back, and therefore favorable to vision;
CHAPTER V.

DIGESTIVE APPARATUS.

§ 82.

The alimentary canal is situated in the cavity of the body, isolated, but is retained in its place by a kind of mesentery which is composed of fibres,\(^1\) or of a thin membrane.\(^2\)

The mouth, which is usually central, is often surrounded by a circle of tentacles.\(^3\) In the Asteroidea, the digestive canal is a large central pouch, an anus and appendages extending into the rays being present in some\(^4\) and wanting in others.\(^5\) In the other Echinoderms, the digestive canal has usually thin walls, is of a variable length, and tortuous quite to the anus.

The position of the anus is quite varied. In the Echinidae, and Asteroidea, it is in the centre of the back, exactly opposite the mouth. In the Holothurioidea, it is at the posterior end of the body; while in the Clypeasteridae, and Spatangidae, it opens laterally upon the margins of the shell. In the Crinoidea, it is near the mouth upon the ventral surface, and in the Sipunculoida, it has a similar position.

The internal surface of this canal has generally been found lined with ciliated epithelium.\(^6\)

§ 83.

With the Asteroidea, and Echinoida, the pedicellariae already described, are used to seize the food and convey it to the mouth. Their ambulacra are perhaps sometimes used in the same way. In the Crinoidea, the furrow of the tentacles, aided by the tentacles themselves, serves well to conduct the food from the arms and pinnules to the mouth.\(^7\)

In the Holothurioidea, and Sipunculoida, there are completely retractile tentacles of a special nature. In the first, they are hollow, pinnated or branched, and, arranged in a circle around the mouth, are attached by their base to the osseous circle and to the elongated vesicles which project into the cavity of the body. These tentacular vesicles contain a liquid, and, in the Asteroidea, where they are upon the ventral surface at the end of the furrows, the rays bend round to the dorsal surface; and again, although Tiedemann (Meckel's Deutsch. Arch. loc. cit. p. 175) thinks these last can distinguish light from darkness, yet it is doubtful if these animals can really see by these organs. They appear, like many other inferior animals, to perceive the light by its action as an excitant upon their skin, and in this way can, like plants, seek the sunlight. The account which Forbes (Hist. of British Star-fishes, p. 139, and Frolic's neue Not. No. 429, 1843, p. 26) has given of *Luidia fragilis-sima*, which, having made its escape by the loss of an arm, looked with scornful eyes upon its persecutor, is pleasant to read, but is far from settling this question.

1 Asteroidea, Echinoida, and Sipunculoida.
2 Holothurioidea.
3 Holothurioidea and Sipunculoida.
4 Asteroidea.
5 Ophiuroidea.
6 According to Sharpey (Cyclopedia, &c., loc. cit. t. 1. p. 616) and Valentin (Wagner's Handworterbuch der Physiol. 1. 1842, p. 493), the internal surface of the stomach and its appendages, of the Asteroidea, has a ciliary movement. Valentin (Monogr. &c. p. 70) has also found ciliated epithelium in the entire digestive canal of *Echinus*.

With *Phascolosoma*, where I have found cilia upon the tentacular apparatus, and with *Comatula*, where Muller (Abhandl. d. Berl. Akad. 1841, p. 233) has found them in the anus, they extend probably through the intestine.

which, by their contraction, is pressed into the cavity of the tentacles for lubrication.\(^2\)

The retraction of the tentacles is due in part to their own contractility, and in part to the numerous muscles, which, arising from the internal surface of the cavity of the body, are inserted into the osseous circle. By these means, it, together with the tentacles, can be retracted into the body.\(^3\) With the Sipunculidae the tentacular apparatus consists of a fringed border on the margin of the mouth, which is also provided with vesicles.\(^4\) In Sipunculus, and Phascolosoma, there are four long muscles, which, arising from the internal surface of the body, pass on to the mouth, and are retractors of the tentacular membrane.\(^5\) It is possible that these oral tentacles serve not only as prehensile organs of food, but also as those of locomotion and respiration.\(^6\)

§ 84.

The mouth of the Comatulinae presents nothing remarkable; but with the Asteroidea, it is covered with hard papilla, projecting from its corners and angles. In the Ophiuriidae, the inverte angles are covered with hard papilla, while the everted ones have calcareous teeth, between which are concealed soft cylindrical tentacles. Immediately behind all of these, the entrance of the stomach is indicated by a membranous sphincter. In the Asteroidea, however, this is wanting, there being a short oesophagus leading directly into the stomach.

With the Echinoida, and Holothurioida, the mouth has a soft circular lip, between which, with the Echinidae, and with the Clypeasteridae, project the points of enamelled teeth.

The mouth of the Echinidae, and Clypeasteridae, has a very remarkable masticatory apparatus. In the first, the calcareous basis which supports the teeth has long been known as Aristotle's lantern. This conical basis is divided into a base and summit; the first being the superior part of the animal itself, while the second is formed by points of teeth projecting from the mouth. It is, moreover, composed of fifteen pieces, five of which are three-sided, hollow pyramids, and so adjusted that they touch each other by their plane surfaces, presenting externally the third surface which is convex. This last has internally a longitudinal furrow, in which is fitted a very long, narrow and slightly-curved tooth. Beside these five principal pieces, which form the jaws of Echinus, there are two other kinds, much more

\(^2\) These vesicles are found in Holothuria and Chirudota; see Tiersehau, loc. cit. Tab. II. fig. 4, c. 6. i.; also the Catalogue of the Museum, London, &c., IV. Pl. XLIX. fig. 1, 2 (Holothuria tubulosa) and the Atlas Zool. du Voyage de l'Astrelabe. Zoophytes, Pl. VIII. fig. 3 (Chirudota jascola).

\(^3\) In Pentacta doliium, I have found only a single cylindrical vesicle fixed to the circle of tentacles.

\(^4\) In Synapta Ducerena (Quatrefages Ann. d. Nat. loc. cit.), these vesicles are entirely wanting.

\(^5\) In Pentacta, there are five large cylindrical muscles arising from the subcutaneous longitudinal ones, and inserted into the osseous circle: they are special retractors of the tentacles; see Meckel, System d. vergleich, Anat. IV. p. 62.

\(^6\) I am inclined to regard as tentacular the two vesicles of Poli, in Sipunculus; and of which Delle Chiaje (Memor. &c. Tav. I. fig. 6, d) received only one, although Grube (Müller's Arch. 1837, p. 251, Taf. XL. fig. 2, P) has since seen both fixed in a space circumscribed by the tentacular membrane.

\(^7\) Grube, Ibid. p. 241, Taf. XL. fig. 1. n. 2, m. m.; and Delle Chiaje, Memor. &c. Tav. I. fig. 3.

\(^8\) The oral tentacles of Synapta Ducerena, which, according to Quatrefages (loc. cit. p. 63, Pl. IV. fig. 1), have suckers on their internal surface, are certainly used as locomotive organs.
§ 85.

The digestive cavity of the Ophiuridae is only a simple stomachal sac, occupying the centre of the hollow disc of their body.

It is divided by walls projecting inwardly, into many cæca, which never extend into the rays.\(^1\)

There are usually ten of these cæca, which in *Astrophyton* are subdivided into numerous smaller cæca.\(^2\)

With the Asteroidae, the stomach is large and has a similar situation; but it sends off radial cæca into the rays.

In those species which have an anus, the digestive canal may be divided into three parts. The stomach is separated into two chambers by a circular, projecting fold. The first of these is the true stomach, and the second sends off the radial cæca. A narrow, short rectum, passing off from the stomach, forms the third part of this canal, and terminates in an anus, situated upon the back of the animal and concealed among points, callosities, &c. This rectum has folds which, of a variable length and sometimes branched, are called the inter-radial cæca, and are situated between instead of in the rays.\(^3\)

In the Comatulinae, this canal consists of a coecum situated at the end of a short oesophagus, and which, after a spiral course about the axis of the body, terminates in an anus having the form of a short tube projecting from the ventral surface not far from the mouth.\(^4\)

In *Comatula europaea*, the axis, around which the digestive canal passes

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1 This apparatus has been minutely described by Tiedemann (loc. cit. p. 72, Taf. X. fig. 1, 2), by Meckel (Syst. d. vergleich, Anat. IV. p. 96), and by Valentin (Monogr. &c. p. 63, Pl. V.). See also the beautiful figure by Rymer Jones (Outline of the Animac. Kingdom. &c. p. 167, figs. 70, 71).
3 Konradi, De Asteriasium fabrica, fig. 5.
4 Meckel, Syst. d. vergleich, Anat. IV. p. 50.
5 See also Tiedemann (loc. cit. Taf. VII.), whose beautiful figures have been copied everywhere; and the original designs of the digestive cavity of *Asteracanthion*, *Archaster*, and *Culcita*, by Mal-ter and *Proscheil* (loc. cit. Taf. XI. XIII.).
6 Upon the digestive canal of *Comatula*, see Heusinger, Zeitsehr. f. d. organische Physik. III. 1829, p. 571, Taf. X. XI.
spirally, consists of a spongy substance, from which projects a lamina like the lamina spiralis of the conch of a snail shell. 5

In Spatangus, the toothless mouth opens into a delicate oesophagus which passes insensibly into a long tube of nearly the same size. This last makes two convolutions in its course, and sends off at about its anterior fourth a very long caecum. The digestive canal, situated between the origin of this caecum and the oesophagus, is of a dark color and has transverse plicae, while the remaining portion below is smooth and of an orange hue. 6

In the Clypeastridae, the numerous spiral turns of this canal are supported by many calcareous laminae situated upon the interior of the shell. 5

In many species of Clypeaster, this canal has at its commencement, transverse folds, and further on numerous lateral cæca, which are separated from each other by lamina like those just described. 5

In the Echinidae the pharynx has very thick muscular walls, and is surrounded by masticatory organs. Upon it succeeds a proper oesophagus, which, after a few convolutions, passes to the anus situated in the centre of the back. The digestive canal is a cæcum given off by this last, and has many spiral turns in the cavity of the body. 5

In the Holothuriidae, the very muscular pharynx is surrounded by the osseous circle. In the Holothurinae, the intestinal canal, which is long and equal throughout, has many turns from behind forwards, ending at last in a large cloaca situated at the posterior part of the body. But in the Synaptinae, it is short and nearly straight, and terminates in an anus having no cloaca. 5

In the Echiuridae 6) this canal closely resembles that of the Synaptinae.

In the Sipunculidae it is long, making its first turn about the middle of the body, and its second near the posterior extremity. The ascending and descending portions of this last pass spirally around each other on their way to the anus which is situated on the ventral surface of the body. 6)

§ 86.

As to the glandular appendages of the alimentary canal, the salivary organs are perhaps entirely wanting in these animals.

In the Holothurinae alone, are there particular appendages opening into its anterior portion, which could be regarded as organs of this nature. In the different genera, species, and even individuals of this family, these appendages widely vary as to form and number.

6 See Meckel, Syst. d. vergleicht, Anat. IV, p. 55, and Delle Chiaje, Mem. &c. Tav. XXV. fig. 12; also Carus and Otto, Erkärtungsstafeln z. vergleicht, Anat. II. IV. Taf. 1, fig. 24, and Wagner, Icon. zool. Tab. XXXII. fig. 8. The nature of the canal figured by Delle Chiaje is yet unknown. It arises from the first portion of the Intestine, and returns to it at its middle portion. It has not been mentioned by Meckel.
7 Jussiz, Monogr. des Scrobic., p. 14, Pl. III. fig. 19, a.
8 Ibid. p. 17, Pl. XXII. fig. 23 (Laganum and Mistella).
9 See Tiedemann and Valentins, loc. cit.
10 The digestive canal of the Holothurinae was first figured by Delle Chiaje and by Tiedemann, loc. cit.; afterwards by Quay and Gaimard (Atlas zool. du Voyage de l'Astrolabe. Zoophytes, Pl. VI. fig. 2, Pl. VII. fig. 5). The cloaca is always wholly attached to the skin by numerous tendinous fibres. In Chirodota fusa the intestine is spiral (Atlas zool. &c. Pl. VIII. fig. 5); but in Synapta Duvernaux it is nearly straight (Quaréscce Cin. &c. Nat. loc. cit. Pl. II.)
11 See the remarks of Forbes and Goodall upon the Anatomy of Thalassoma and Echiurus (Frale's new Novizen, No. 392, p. 274, fig. 12).
12 The alimentary canal of Sipunculus nudus, and of Echinothrix, has been faithfully described by Delle Chiaje (Memor. &c. I. p. 9, Tav. I. fig. 5, 6; p. 128, Tav. X. fig. 11) and Graube (Müller's Arch. 1857, p. 249, Taf. XI.). I have found a similar intestine in Phascolosoma granulatum.
In *Holothuria tubulosa*, they are cylindrical, pure white, and very numerous, being united in bundles which are attached to the digestive canal near the pharynx by short white pedicles.\(^1\)

In *Pentacta dolium*, there is usually only one of these organs,—a small, white, curved horn, which sends to the pharynx a very tortuous canal, which is widely removed from the excretory duct of the genital organs.

The whiteness of these organs in Holothurinae is due to a reticulated calcareous skeleton in their walls.\(^2\)

The radial caeca of the Asteroidae ought probably to be regarded as hepatic organs. They are often quite developed, extending as a double canal from the stomach into each ray. Their walls have numerous small botryoidal vesicles, which secrete a yellow liquid. Usually each of these ten liver-like organs arises from the stomach by a proper canal; \(^3\) but in some, two of them connect with this organ by a single canal.\(^4\)

With those Asteroidae which have an anus, there is another series of glandular appendages, the inter-radial caeca, which pass off from the rectum. Their function is not yet known. They contain a brownish liquid, in which, with *Asteracanthion rubens*, no uric acid has been found. In *Astrogonium*, *Solaster*, and *Asteracanthion*, these organs are branched, and only two in number.\(^5\)

In *Archaster*, and *Culcita*, there are five; but in *Culcita coriacea*, each of these is divided dichotomously into two other long botryoidal caeca, which, separated by a septum, are spread out between the rays.\(^6\)

In *Astropecten*, \(^7\) which is without an anus, there are sometimes found two short, analogous caeca, which open into the base of the stomach by a common orifice. But in *Luidia*, which is also without an anus, these organs are entirely absent.\(^8\)

In the other Echinoderms, which are entirely without these glandular appendages, the walls of the alimentary canal probably secrete the fluid requisite for digestion, and thus supply also the want of the hepatic organ.\(^9\)

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1. It has already been shown that the cylindrical vesicles of *Holothuria* taken by Curier and other naturalists for salivary organs do not communicate with the digestive canal, but rather with the tentacles. The white appendages of *Holothuria tubulosa* were first described as testicles by *Delle Chiuse* (Memor. &c. I, p. 97, Tab. VIII, fig. 1 o.), and Tiedemann (loc. cit. p. 29, Tab. II, fig. 6, p.) assigned to them the same function. It is certain that they have no testicular character, although I cannot affirm that they are salivary organs. They have been figured, in *Holothuria atrera*, by Jäger in his dissertation : De *Holothuris*, Tab. 1. fig. 2, e. e.

2. This calcareous tissue has been observed by Jäger (loc. cit. p. 38, Tab. III, fig. 7), by Wagner (Frosept's neue Not. No. 249, 1859, p. 99), and by Krohn (Ibid. No. 355, 1841, p. 65). This last observer, who affirms that these organs are in connection with the great circulatory vessel surrounding the digestive canal, compares them to the stony canal of the Asteroidae.

3. In *Astropecten aurantius*, according to Tiedemann (loc. cit. Tab. VII, or, Wagner, Icon, zoolog. Tab. XXXIX, fig. 1). It is the same, also, in *Archaster, Culcita, and Luidia*; see Muller and Troeschel, loc. cit. p. 122, Tab. XI, fig. 2; Tab. XII, fig. 1.

4. *Asteracanthion*; see Konrad, De Asteri- rum fabrica, fig. 1; and Muller and Troeschel, loc. cit. Tab. XI, fig. 2. 5. See Muller and Troeschel, loc. cit. p. 132, Tab. XI, fig. 1 (*Asteracanthion rubens*); an entire group of these rectal caeca of *Asteracanthion goniolus*, has been figured by Konrad, loc. cit. fig. 1, o.

6. Muller and Troeschel, loc. cit. p. 132, Tab. XI, fig. 2; Tab. XII, fig. 1.

7. Tiedemann, loc. cit. Tab. VII.


9. According to Valentin's figure of the intimate structure of the digestive membranes of *Echino- nus*, they are lined with hepatic epithelium, like that of the Lamelibranch, and that of the Polyzoa, already mentioned (Monogr. &c. Pl. VII, fig. 125, 131, 133).
CHAPTER VI.

CIRCULATORY SYSTEM.

§ 87.

The vascular, sanguineous system of these animals is yet imperfectly known. The constant confusion and imperfection of its descriptions are probably due to the fact that it has not been carefully distinguished from the respiratory system; and also, as was true of the Aculephae, because it has been confounded with the aquiferous system, which is usually present. 1

From all the old and new researches upon this subject, it is evident that all the Echinoidea have an isolated system of this kind, composed usually of both an arterial and venous trunk, between which there is, in some species, an organ like a heart.

§ 88.

In the Crinoïdea, there is, at the base of the calyx, a heart-like saccule, from which pass off vessels into the central cavity of the arms, the cirri, and the pedicle when it is present. From its centre, another vessel is given off for the spongy axis of the cavity of the body. 2

The Asteroïdea have three vascular rings, one of which is under the skin of the back, while the other two are beneath, around the mouth. Between these vascular rings there is a long muscular heart, which, united to the calcareous pouch or cord, extends from the madreporal plate to the mouth.

It is probable that the Asteroïdea, which have many of these plates, have also many calcareous cords and hearts. 3 From these vascular rings numerous other vessels are sent off, some to the stomach and its appendages, and the genital organs, and others to the ambulacra and their vesicles.

1 The extended, and in some respects contradictory, works of Tiedemann and Delle Chiave (loc. cit.; see, also, McKeel, Syst. d. vergleich. Anat. V. p. 23; and Sharpé Cycloped. &c. II. p. 41) have not, for reasons which may be stated, cleared up this point. The same may be said of what relates to the blood of these animals, for it has been confounded in part with the ambulacral liquid belonging to the aquiferous system. See Wagner, Zur vergleich. Physiol. der Blute, 1833, p. 28.

2 The observations of Delle Chiave (Memor. Acc. II. p. 349) and of Carus (Anabéki zur Natur. u. Heilkunde, 1829, p. 132) and Lehrb. d. vergleich. zoöot. 1834, p. 673) do not give correct ideas upon the mode of direction of the circulation of these animals; for it is evident that they did not see it, but only the vibratile phenomena of the aquiferous system.

3 The vascular system of Comatula and Pentacria has become known through Heusinger (Gesb. f. organisch. Physik. III. 1829, p. 377, Taf. X. XI.) and Muller (Abhandl. d. Berl. Akad. 1841, p. 195, 239, Taf. V.). The membranous canal, situated beneath the nervous branches of the arm, and directly above the calcareous articulations, and the passage of which through the arm into the calyx Muller (loc. cit. p. 233) has not been able to clearly make out, is probably a blood-vessel. It is yet unknown how the blood of these vessels is distributed to the organs.

4 As in Echinaster solaris, and Ophiaster multifloris; see Muller and Troschel, loc. cit. p. 134.

5 According to Tiedemann (loc. cit. p. 49, Taf. VIII.), the lower extremity of the heart of Astropecten aurantium opens into the vascular ring which surrounds the mouth. This last sends arterial branches to the stomach, the cocca, and the genital organs; the superior extremity of the heart communicates in like manner with another vascular ring upon the back, and which receives the veins of the organs just mentioned. From a third and reddish vascular ring, situated directly under the skin of the mouth, Tiedemann has seen pass into each ray a vessel placed superficially in the furrow of the ambulacra, but he did not ascertain
In the Echinidae, the heart is long, and attached to the esophagus.

In Echinus, it has several saccular enlargements, and internally has a cavernous aspect, due to numerous irregularly arranged septa. At each of its extremities there are two vascular rings. The two below are situated on the top of the lantern and surround the esophagus, while the two above surround the anus; all belong probably to the arterial and venous systems. One of these last sends off five branches to the genital organs, while the other receives one of the two trunks which pass along the whole length of the intestinal canal. Two longitudinal vessels, which send off branches right and left, pass between each of the five pairs of ambulacral organs. These are, probably, a branchial artery and vein.

In the Holothuriae, the vascular system, which is without a heart, is very distinct. An aortal trunk arises from the vascular ring, which surrounds the esophagus, and ramifies upon the intestine and the genital organs. By a reunion of these ramifications, a second trunk like a venous cava, is formed. This divides into two arteries, which ramify upon the branchiae, and from which arise two branchial veins, which return to the aorta.

With the Sipunculidae, and Echiuridae, there is a main vascular trunk, which, after sending off laterally small branches, passes along the ventral median line, above the digestive canal.

The relations with the rest of the vascular system. Moreover, he has taken for an isolated, special sanguineous system belonging to the ambulacra, the branchial system, which communicates directly with the ambulacra, and which forms a third ring, situated between the two sanguineous ones of the mouth.

Volkman's description (Isis 1837, p. 513) is wholly different. According to him, the vascular trunks of the superficial ring, and which are located in the foræ of the arms of Asteracanthus violaceus, send off laterally ambulacral branches; the oral ring, situated more deeply, sends off branches, which, passing through the cavity of the body, go to the rays and ambulacra, and freely communicate with the cavity of these last. This same ring has also an anomalous connexion with that of the branchial. According to this, the circulation occurs, he thinks, in the following manner: The heart sends the blood into the superficial oral ring; thence it passes by the vessels in the foræ of the arms into the cavity of the ambulacra; these last, acting as venous hearts, send it, by the vessels in the interior of the rays, to the second oral ring, from which it passes to the third and dorsal ring, and thence to the heart.

It is evident that Volkman has taken a part of the aquiferous system for that of the sanguineous one; and it is probable that he did not observe the second oral ring. No correct idea can be formed of the distribution of the arteries and veins of the Asteracanthus, or of their vascular system in general, except by carefully separating it from the aquiferous system, and considering the fact that the blood-vessels do not open into the ambulacral vesicles, but probably are spread as a capillary network upon their walls.

The heart of Echinus, which is accurately described by Valentin (Monogr. & c. p. 92, PI. VIII), is attached to the esophagus by a kind of mesentery. 5

5 These details are supported by Valentin (loc. cit. p. 95), who has already added much to the labors of Tiedemann and Delile Clajus upon the sanguineous system of Echinus, although, like his predecessors, he has been deceived as to its connections.

The received opinions upon the circulation of these Echinoderms are, therefore, hypothetical. The nature of the five glandular organs, which Valentin has been able to unite with one of the two vascular rings situated upon the lantern, is very problematical (Monogr. & c. p. 94, PI. VII. fig. 119, l. 120).

6 See Tiedemann, loc. cit. p. 15. The sanguineous system of Synagти Davenaen, as described by Quadrat (loc. cit. 1838), corresponds properly, to the aquiferous system of Holothuria, which Tiedemann also has taken for a special sanguineous system of the skin and ambulacra. However, we shall not notice further both of these systems.

7 For the sanguineous vascular system of Sipunculus and Echichius, see Grube and Krohn (Muller's Arch. 1837, p. 248; 1839, p. 559), also Forbes and Goodric (Quar. J. Nat. Hist. 1824, loc. cit.), The vascular trunk embraces there the nerve so closely, that it is necessary not to overlook one, or confound both together.

Quartefages has found in the anterior part of the body of Echinus Gaertneri three heart-shaped swellings of the blood system, namely, a ventral heart upon the dorsal vessel, a dorsal heart upon the dorsal vessel, and a mesenteric heart situated beneath the digestive tube. This last communicates with the ventral heart by a median vessel, and with the dorsal vessel by a small vascular ring; see Ann. d. Sc. Nat. loc. cit. p. 322, PI. VII. fig. 1.

* § 88, note 6.] See, for the vascular system of the Holothurioidea, Muller (Arch. 1839, p. 229), who has carefully studied it with the larger Synagmites. He confirms Tiedemann's observation above quoted as to the general distribution of the vessels, and especially as to the presence of a spiral circulatory system, which, as is well known, Quartefages has supposed to be wanting. - Ed.
THE ECHINODERMATA.

CHAPTER VII.

RESPIRATORY SYSTEM.

§ 89.

The respiration of the Echinoderms is performed in various ways. These are: 1. By exclusively respiratory branchiae. 2. By organs serving at the same time other functions. 3. By means of water passing through the openings of the skin into the cavity of the body, and aerating the blood through the capillary vessels of the viscera.

With the Asteroidea, Synaptinae, Sipunculidae and Echiuridae, every individual has always two of these modes of respiration, and sometimes all three, as with the Echinidae and Holothurinae.

§ 90.

I. Organs which are exclusively respiratory are found in the Echinidae, Holothurinae, and Echiuridae. They consist of external branchiae in the first, and internal in the last two.

The external branchiae of the Echinidae are situated upon the soft membrane of the mouth, being formed of five pairs of arborescent, hollow lobules.\(^1\) They are contractile, but cannot be retracted within the body. They are covered both internally and externally with ciliated epithelium.

The cavity of each communicates with that of the body by a large oriifice situated on the internal surface of the oral membrane.\(^2\) By this means they are bathed with water upon both of their surfaces. Their walls contain a coarsely reticulated calcareous skeleton,\(^3\) and without doubt, also a capillary net-work belonging to the branchial vessels.

The internal branchiae of the Holothurinae arise as two tubes from the cloaca of the intestinal canal, and send off, through the whole cavity of the body, numerous coecal branches.\(^4\) In Holothuria tubulosa, one of these tubes is closely connected with the turns of the intestine, while the other is attached to the inner walls of the body. With the first, especially, may be perceived the ramifications of the branchial vessels. They are also covered with ciliated epithelium, and their contractile and expan-

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\(^1\) The ramified organs of the Echinidae, already known by Tiedemann (loc. cit. p. 75, Taf. X. fig. 3, d. d.) and Delte Chieje (loc. cit. II. p. 328), have been more exactly described by Valentin (Monogr. &c. p. 82, Pl. IV. fig. 57; Pl. VIII. fig. 42), and by Erdt (Wiegmann's Arch. 1842, I. p. 59, Taf. II. fig. 12, 13).

\(^2\) Valentin, loc. cit. Pl. VII. fig. 133, 1.

\(^3\) Valentin, loc. cit. fig. 143; and Erdt, loc. cit. fig. 13.\(^2\)

\(^4\) The branchiae of Holothuria tubulosa have been very well described by Tiedemann (loc. cit. p. 11, Taf. II. or Wagner Icon. Zool. Tab. XXXII. fig 9), and by Delte Chiege (loc. cit. Taf. VIII. IX.). See also Atlas Zool. du Voyage de l'Astrolebe. Zoophytes, Pl. VII. fig. 2, 3, p. (Holothuria annulos) and Pl. VII. fig. 3, c (Clod-oliades spinulosus). Pentacta dolothum has similar organs. According to Center (Anat. Comp. VII. 1849, p. 630) there is only a single branchia in the other remaining Holothurinae.

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\(^{*}\) [§ 90, note 3.] See, in this connection, Müller (Arch. 1850, p. 122), who has confirmed Valentiin's observations as to the structure of the external gills. — Ed.
sive power, united with the action of the cloaca, enables them to receive into and expel from their interior the water of the sea.\(^{6}\)

The internal branchiae of the Echiuridae consist of branchless tubes. In *Echiurus vulgaris*, the two branchiae, which are very movable and open into a kind of cloaca, have, on their exterior, infundibuliform, ciliated protuberances; and to each of these there is internally a corresponding ciliated sac, capable of being inverted. The very bright-red, vascular network which is spread over these branchiae, communicates with the great ventral vessel at the posterior extremity.\(^{6}\)

§ 91.

II. Among the organs which are not exclusively respiratory, are the ambulacra of the Echinodermata pedata, and the oral tentacles of the Holothuroidea and Sipunculidae,—organs which are used also for prehension and locomotion.

These ambulacra and tentacles have always a cavity which communicates directly with the proper vascular, aquiferous system. Their whole interior is covered throughout with ciliated epithelium.

This aquiferous system has, until recently, been taken by anatomists as a special vascular one, or confounded with it. Its water serves partly to distend the ambulacra and tentacles, as shown above (§ 77), and partly for respiration, which is performed by the vesicles over which ramify the branchial vessels. These vesicles are therefore like internal branchiae, their vessels being bathed by the water of the sacs, and that of the cavity of the body. Usually this system consists of a ring situated between the vascular rays of the mouth, which sends canals to the oral tentacles and to the sides of the body. These canals always pass along by the rows of ambulacral vesicles, with which they communicate by lateral branches.

§ 92.

In the Echinodermata pedata, this aquiferous system has the following modifications:

In the Crinoidea, and Ophiuridae,\(^{1}\) only traces of it have been found.

In the first, there is an apparently aquiferous canal for the tentacles, situated directly under their furrow. This may be regarded as forming a part of such a system. In *Pentacrinus*, it is simple, but in *Comatula*, it is divided at several points by simple septa.\(^{2}\)

In the Asteroidae, this system is highly developed, the central ring being provided with pediculated and often elongated vesicles.\(^{3}\) The main

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\(^{6}\) There is found, but inconsistently, it would appear, upon the trunk of the branches of some Holothuriae, particular polycnudated coeca, which in *Holothuria marmorea* have been regarded as urinary organs by Jauer (De Holothuris, &c., Tab. III, fig. 9, g.). But they require further investigation.

\(^{6}\) Forbes and Good sir (Forrier's neue Not. No. 392, p. 277, fig. 12, c. — 19).

\(^{1}\) From the figures of *Della Chiage* (Occ. cit. Tav. XXI. fig. 17) it would appear that Ophiurus has an aquiferous system.


\(^{3}\) These gyroform vascular appendages are always situated between the principal vessels of the rays, varying both as to number and volume, and being sometimes entirely wanting. *Astropeten bispinosus* has only five; *Astrelius verruculosus, Astropeten pentacanthus, and Asterocanthus glaciatus*, have ten, in pairs. In this

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\* [§ 90, note 5.] For many new details upon the respiratory system of the Holothuroidea, see *Müller, Arch. 1850, p. 129-155 (Synapta, Chirodota, and Molpadia).* — Eo.
trunks from this oral ring pass along the furrows of the rays close to their external surface. The ambulacral vesicles into which their lateral branches open, are sometimes simple, or, from a kind of suckation, have a heart-like form.

In the Echinoidea, the oral ring wants the pyriform appendages, and its main trunks pass along the internal wall of the shell. The ambulacral vesicles of the oral membrane are conical; but the others are flattened, overlap each other in a tile-like manner, and have a distinct branchial, vascular network.

The aqueous oral ring of the Holothurinae has hollow appendages (tentacular vesicles) projecting into the cavity of the body. It has also, in many species, a larger, longer, and sometimes double, coecal vessel (Amphulla Poliana). Opposite the tentacular vesicles, the ring sends off to the oral tentacles, vessels which are often arborescent and comparable to external branchiae; while, between these vesicles, arise five other vessels which descend along the internal surface of the body. As usual, they send off lateral branches to the generally very small ambulacral vesicles.

In a few species only of the Synaptidae, the aequiferous ring has hollow appendages. From it pass off vessels both to the tentacles and to the sides of the body. As the ambulacra are here absent, the five main trunks do not give off lateral branches.

In the Sipunculoidea, the aequiferous system is least developed. As yet there has been found only a liquid moved by vibratile cilia in the doubly-laminated cavity of the lobulated tentacles of the Sipunculidae. With this cavity, the vesicles of Poli communicate, thus indicating the presence of an aequiferous system.
§ 93.

III. In nearly all the Echinoderms, as has been seen, all the viscera are bathed with water which certainly affects their delicate blood-vessels. It is very probable that from ciliated epithelium covering the entire cavity of the body and the viscera this water circulates in a definite manner. It is rejected at last through many respiratory openings, through which also fresh water is introduced.

In the Ophiuroida, there are in each inter-radial space two or four large openings of this kind, leading into the cavity of the body. (3)

In the Asteroida, water passes freely in and out the cavity of the body, through small contractile trachean tubes, which have been known for a long time, and which are very numerous upon the back. They are covered within and without with ciliated epithelium, and have an opening at their extremity. (2) As yet it is unknown how the cavity of the body of the Echinodermata and Holothurioidea receives the water. Only in Synapta Duvernaeac, have there been found proper respiratory openings; these are four or five papillae, covered with cilia, concealed at the base of the oral tentacles, and connecting with the cavity of the body through a narrow canal. (2) In the Sipunculidae, the water is received through an opening at the posterior end of the body. (6) *

CHAPTER VIII.

ORGANS OF SECRETION.

§ 94.

The Echinoderms appear to have special organs of secretion. In different parts of the body there are glandular organs, the real nature of which, however, has not yet been determined. (1)

by the presence of delicate and tortuous vessels, observed by Grube (Müller’s Arch. 137, p. 235) upon that of Sipunculus nudus. The same conclusion might be drawn from the liquid moved by cilia observed by myself in the interior of the tentacular lobules of Phascolosoma groundi. Grube (Müller’s Arch. 137, p. 231, Taf. XI. fig. 2, P.) has seen in Sipunculus nudus the two vesicles of Völli, communicating with the cavity of the tentacular membrane.

1 Müller and Proscheil, loc. cit. Taf. IX. X.
2 Ehrenberg, Abhandl. d. Berl. Akad. 1856, Taf. VIII. fig. 12, c., and Sharpey, Cyclopaedia of Anat. &c. I. p. 616, fig. 298, G.
4 The manner in which the water enters into the interior of the Echinodermata is not quite clear to me from the description of Forbes and Goodair (Proc. new Nat. No. 304, p. 277).
5 The attention has already been directed to these glandular organs, when speaking of the parts to which they are attached. The calcareous sac, or stone canal as now understood, of certain Asterinae, can scarcely be regarded as organs of secretion.

* [End of § 93.] In Echinocomaunia and Clypeaster Agassiz has observed that trachean tubes, similar to those of the Asteridae, perform the function of carrying the water in and out of the body. They are situated chiefly along the margin of the disc, emptying first into a circular tube, analogous to the circular tube of the Discophora, from which extend ramifications into the main cavity of the body; see Compt. rend. 1847. — Ed.
CHAPTER IX.

ORGANS OF GENERATION.

§ 95.

Although most Echinoderms have extraordinary powers of reproduction, yet this, apparently, is not for the multiplication of the individuals, for they do not reproduce either by fissuration or by buds.

The Holothuroidea alone, perhaps, form the exception. All propagate by the sexual organs of separate male and female individuals, and hermaphroditism is very rare.

The eggs which are usually round, are covered by a thin chorion, and contain beside a little albumen, a variously colored vitellus with its germinal vesicle and dot. The sperm is always milky, and the spermatic particles which are unaffected by sea-water, are nearly always composed of a round or oval, rigid body, to which is attached a delicate, very active tail.

§ 96.

Externally, the organs of both sexes exactly resemble each other, and especially during the interval of procreation; but at the sexual epoch they often differ in color. Their situation is very varied, and they are composed of simple or branched tubes, with proper excretory ducts. These last, however, are sometimes wanting, and then the contents of the former escape by rupture, and, falling into the cavity of the body, pass out through the respiratory openings.

Here, as in the Polyps and Acalephs, the copulatory organs being absent, the water is the medium of the fecundation of the eggs, by bringing the spermatic particles in contact with them.

1 The Holothuria, which, when captured, discharge all their viscera through the mouth, can, according to Doherty (Frölich's neue Nyt. No. 331, p. 1), not only reproduce all these, but also can divide spontaneously into two or more parts, each of which becomes a complete individual. This multiplication by fissuration occurs also, perhaps, with Synapta Duverneia: see Quatrejages, loc. cit. p. 26.

2 See the eggs of Comatula Europaea (Müller, Abhandl. d. Berl. Akad. 1841, Taf. V. fig. 17), of Asteracanthus violaceus (Wagner, Protomonas, &c., Tab. I. fig. 3, or Carus and Otto, Erläuterungsblät., II. V. Tab. I. fig. 1), of Echinus liebes and sphera (Valentin, Monogr. &c. fig. 167, 169), of Holothuria tubulosa (Wagner, Icon. zoöt. Tab. XXXII. fig. 12), and of Synapta Duverneia (Quatrejages, loc. cit. Pl. V. fig. 1).

3 See, for the spermatic particles of Asteracanthus, Solaster, and Echinus (Külliker, Erläuterungen, loc. cit. fig. 1—4, and Valentin, Monogr. &c. fig. 168), of Holothuria and Synapta (Wagner, Icon. zoöt. Tab. XXXII. fig. 15, and Quatrejages loc. cit. Pl. V. fig. 5). Those of similar form have been seen in Comatula by Müller (Monatsberichte d. Berl. Akad. 1841, p. 189, or the Abhandl. of the same, loc. cit. p. 230). According to Valentin (Repertorium, 1841, p. 300), those of Spatangus violaceus have an elongated body, pointed in front, with a very delicate hair-like tail. Those of Ophiotherina longicauda, and Ophiothrix fragilis, according to my own observation, have a round body, with an equally delicate hair-like tail.

* [§ 95, note 3.] The spermatic particles of the Echinoderms are developed, like those of the other Radiates, in special cells, and like them also have, I think, invariably a cercaria-form. The differences in the shape of the head of these particles are wide, and of zoological import. Thus it is sometimes round (Asterias, Uraster), sometimes pyriform (Echinocidaris), and sometimes long-conical (Mellita). — Ed.
§ 97.

In the Crinoidea, these organs, in the form of tubes, are situated under the soft perisoma of the pinnulae, and probably are without proper excre- 
tory ducts.\(^1\)

In the Ophiuriidae, they consist of lobular, pedunculated sacs, which are 
suspended in pairs in the inter-radial spaces of the disc.

These ten organs are usually deeply fissured, and the lobules thus formed 
appear as so many proper sacs attached to the peduncle.\(^2\) These last are 
sometimes subdivided also.\(^3\)

Sometimes each organ, divided in its whole length into lobules, is turned 
in the shape of a ram's horn.\(^4\) The peduncle of these organs is directed 
towards the mouth, but it is yet uncertain whether their contents escape 
this way or fall into the cavity of the body. In the first case, the pedun-
cele would be the excretory duct;\(^5\) and in the second, the eggs and sperm 
would escape through the respiratory openings.\(^6\)

In the Asteroidea these organs consist of varicose lobular sacs, situated 
in the angles of the inter-radial spaces.\(^7\) In those species which are without 
an anus, there are no proper genital openings;\(^8\) these openings are also 
wanting in those Asteroidea which have an anus.\(^9\) In these last, the sperm 
and very small eggs pass into the cavity of the body, and probably have 
their escape through the respiratory openings.\(^9\)

But in some species,\(^10\) there are upon the back and near each angle of 
the inter-radial spaces two small approximated plates, perforated by small 
openings (Luminæ cribratae). These are the simple openings of these 
organs, which here consist of multi-ramose sacs, situated all along each side 
of the inter-radial septa, to the common duct which opens through one of 
the plates.

The number of these genital sacs varies widely in the different genera 
of the Asteroidea. In many, a single trunk of them hangs on each side of 
the inter-radial septa;\(^11\) in others, there is a whole row of them;\(^12\) and 
in others still, there are two rows attached to the dorsal surface of the cavity 
of the body, and extending into the rays.\(^13\)

In the Echinoidea, these organs descend along the internal surface of 

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1 The development of the genital organs of Comatula was first observed by Dujardin, who 

assents that the red vesicle situated on both sides of the tentacular furrows secretes, during the epoch 
of rat, a very beautifully red liquid (I'Insch. No. 119, p. 289, or Wiegman's Arch. 1838, II. p. 297). 

Thompson has seen the eggs of Comatula escape in clusters through the openings of the pin-


8); while, according to Müller, they escape by rupture (Abhandl. d. Berl. Akad. 1841, p. 254, Taf. 

V. fig. 17, 18).

2 Ophioderma longicauda, and Ophiolapis scolopendraeæ; see Rothke, Fritsche's neue Nat. 

No. 293, p. 63; and, Nomenclat. Schrift. d. Natur-

forsch. Gesellesch. in Danzig. III. Hft. IV. 1842, p. 116, Taf. II. fig. 3, 4.

3 Ophiocoma niger; see Rothke, Danzig. 

Schrift. &c. loc. cit. Taf. II. fig. 5-7.

4 Ophiopus griseus.

5 Rothke, loc. cit.

6 Müller and Troschel, loc. cit. p. 133.

7 Müller and Troschel have very interesting 
details upon the various arrangements of the geni-

tal organs of the Asteroideæ (loc. cit. p. 122).

8 As in Astrotpecten and Luidia.

9 As in Ophiaster.

10 According to Sars, the ventral surface of the 
disc and arms of the female Echinaster sanguinolentus and Asteracanthion Mulleri have at cer-
tain times a kind of incrusting cavity, in which the eggs remain during their development. He thinks 
they get there from the cavity of the body, through particular openings upon the ventral surface of this 
last; see Wiegman's Arch. 1844, I. p. 169, Taf. 

XI. fig. 1, 2.

11 The genital parts of Echinaster sanguinolentus 
have been described with much detail by Sars, 

12 Asteracanthion tuberculæ, and Solaster pop-
pous; see Müller and Troschel, loc. cit. Taf. 

XII. fig. 2-4.

13 Echinaster, Astrogamium, Asterias, and 

Cenoliticus.

14 Astrotpecten, Oreaster, and Culeita; see 

Tiedemann, loc. cit. p. 61, Taf. VIII. L. J.

15 Asteraster, Charontaster, Luidia and Ophidi-

aster; see Müller and Troschel, loc. cit. Taf. 

XII. fig. 5.
the shell, filling the empty spaces between the double rows of ambulacral vesicles.

They consist of widely ramified, deeply interlocked coeca, having always proper excretory ducts, which open upon the genital plates of the back of the shell. These are here always five of these organs, and the genital plates, alternating with the ocellary ones, surround the anus. In some species of the Clypeastridae, and Spatangidae, there are, perhaps, only four of these organs, judging from that number of the plates. In the Holothuriae, these organs have a very different arrangement. They consist of widely-branched coeca, floating, as loose clusters, freely in the cavity of the body, and opening through a single common-excretory duct, situated below the osseous circle, and between the oral tentacles.

The testicle, which is of a whitish color, consists of a cluster of cylindrical sacs, branched and interlocked with each other. But the ovary is pale red, very long, branched, a little flattened, and extends even to the posterior end of the body.

As the only exception among these animals, the Synaptinae are hermaphrodites. But it should be stated that we know of them only through Synapta Ducerrenae. It is said that here the testes and ovaries are united in one and the same organ.

Three or four long cylindrical sacs float in the cavity of the body, and have an excretory duct which opens back of the osseous circle. At the ebron of procreation, vesicular prolongations appear on their interior surface, in which are formed spermatid particles. The spaces between these prolongations are filled by a pultaceous mass, in which appear eggs.

In the Spunculidae, and Echiuridae, there are only two or four simple cylindrical contractile pouches attached to the ventral wall. It is yet undetermined whether their contents escape by rupture, or through special openings.

[5 97, note 23.] For the sexual organs of Spunculus, see Peters (Mulder's Arch. 1850, p. 9]
The few observations hitherto made upon the embryology of the Echinoderms belong solely to the Asteroidea. Here, the vitellus undergoes the usual segmentation, and then is changed into a long, cylindrical, infusorial embryo, covered with cilia.

A few days after, four papillae are formed upon the anterior part of the body, and by these the embryo is attached to the walls of the incubating cavity (Bruthöide). It then begins to be flattened laterally, and upon one of these lateral surfaces, ray-like tentacles appear, while the margin of the body forms five angles, upon the extremity of each of which is a red pigment dot. Then the cilia upon its surface disappear, and the young individual, deprived of its papillae and set free, moves about by its ambulaeae. 

§ 98.

1 These interesting observations of Sars (Wiegmann's Arch. 1857, I. p. 401, 1844, I. p. 169, Taf. VI. figs. 4-22) were made upon Echinoidea. Aeginae, and Asteroidea. Müller. He has also observed that during the development, the point of attachment is gradually changed, until it reaches the back; thus supporting the view that the madreporal plate is the relic of this last, which, in Comatula, has been well compared by Müller and Trosckel (Synt. d. Asteridea, p. 124), to a buton, since from it the young individuals are attached by a pedicle, as Thomson has shown upon (formerly) Pentacorona Europea; see Zolitzch, Die Organische Physik. Physik. 1825, p. 55, and the Edinb. new Philos. Journ. 1836, p. 216, or Fro-riep's neue Not. No. 1057, 1836, p. 1. The assertion of Sars (Wiegmann's Arch. 1844, I. p. 170) that the animal which he formerly called Bipinnaria asterigera (Beskrivelser, &c., p. 57, Tab. XV. fig. 40) is probably only a developing Asteroidea orbital with a great swimming appa- ratus, deserves to be considered. The remark of Dugett (Froirip's neue Not. No. 321, p. 2) that the young of Holothuria are of the size of bar- ley-corns, and resemble white maggots, is not one that affords no new data upon the development of these animals. There remains, therefore, a vast field open to observers concerning the development of the Echinoderms.

Sars (loc. cit. p. 47, Taf. VIII.) has furnished numerous data on the development of Echinaster. It appears, moreover, that all the Asteroidea are not developed after this type; for: Karen and Danielsen (Ann. d. Sc. Nat. VII. 1847, p. 347, Pl. VII. fig. 7-9) have shown that Bipinnaria asterigera first observed by Sars, is a young As- teroid which moves by means of a particular

Peters has found that the fine whitish line de- scribed by Girard as tending conoides with the blood- vessel of the intestine is an ovisac, being filled with ova, which move along by the action of the cilia with which it is lined. Connecting with this ovis- duct are botryoidal appendages, situated on the intestine, and filled with eggs; these are the ovaries. The eggs, when matured, escape into the general cavity of the body, and thence are transferred outward-ward through two brownish tubes, which open externally, and whose internal extremity is not closed, as has hitherto been supposed, but opens into the general cavity of the body. These tubes, or ovisacs, have been regarded hitherto as respir- atory or secreting organs.

Krohbn (Ibid. 1850, p. 388, Taf. XVI.) has found the fine whitish line described by Girard as tending conoides with the blood-vessel of the intestine is an ovisac, being filled with ova, which move along by the action of the cilia with which it is lined. Connecting with this ovis- duct are botryoidal appendages, situated on the intestine, and filled with eggs; these are the ovaries. The eggs, when matured, escape into the general cavity of the body, and thence are transferred outward-ward through two brownish tubes, which open externally, and whose internal extremity is not closed, as has hitherto been supposed, but opens into the general cavity of the body. These tubes, or ovisacs, have been regarded hitherto as respir- atory or secreting organs.
The first condition of every Echinoderm is the same,—an oval, ciliated body, resembling an infusorial animalcule, and without external organs, or distinction of parts. This is the starting-point, and upon it succeed variations according to the different families. Upon this ciliated body are developed, at one part, peduncles for its attachment to other bodies, while the rest of the form increases in size, and assumes a star-like form.

The larve thus formed may be divided into two groups:

1. Those of the Ophiuridae and Echinidae.

2. Those of the Asteroidea and Holothuridae.

The first are somewhat hemispherical bodies, with one edge of their truncated side prolonged into a single flat and wide process, which carries the mouth and esophagus; while from the opposite extremity project rods, of four, eight or more in number, and which form the internal skeleton. (See Ueb. d. Ophiurenlarven d. Adlirt. Meeres. Taf. I. II.)

These larve have a globular stomach in their hemispherical portion, and from which proceeds a short intestine terminating in a circular anus. They have, moreover, a ciliated fringe, which consists of a ridge covered with large cilia, passing above the mouth and before the arms, completely encircling the body in an oblique manner.

With the second group there is no internal calcareous skeleton, and they form Muller's Auriculata (of the Holothuridae), and Bipinnaria (of the Asteroidea).

The first of these are concavo-convex bean-shaped bodies, with an irregular transverse fissure answering to the hilum of the bean, in which the mouth is placed. The margins of this fissure are ciliated; the anus opens on the ventral surface.

The Bipinnaria closely resemble these last, but they have a distinct ciliated circle in front of the mouth; as their increase in size, the anterior part of their body is covered with long processes, which vary according to different forms.

Out of these larve, all of which have a strictly bilateral symmetry, the more or less radiate adult Echinoderms are developed by a process which is a sort of internal gemmation.

The changes and variations of this metamorphosis I will give in Muller's own words:

"1. The change of the bilateral larva into the Echinoderm takes place when the larva yet remains an embryo, and is universally covered with cilia, without a ciliated fringe. A part of the body of the larva takes on the form of the Echinoderm; the rest is absorbed by the latter (a part of the Asteroidea, Echinaster, Asterecanthion, Sars).

"2. The change of the bilateral larva into the Echinoderm takes place when the larva is perfectly organized; that is, possesses digestive organs and a special ciliated fringe.

"The Echinoderm is constructed within the Platex like a picture upon its canvas or a piece of embroidery in its frame, and then takes up into itself the digestive organs of the larva. Hereupon, the rest of the larva vanishes (Ophiura, Echinus), or is thrown off (Bipinnaria).

"3. The larva changes twice. The first time it passes out of the bilateral type with lateral ciliated fringes into the radial type, and receives, instead of the previous ciliated fringes, new locomotive larval organs, the ciliated rings. Out of this pupa-condition, the Echinoderm is developed, without any part being cast off (Holothuria, and Asteroidea).

"If we call embryonic type the condition in which the animal leaves the egg, and when the internal organs are not yet developed, we have four stages or types,—the embryonic type, the larval type, the pupa type, and the Echinoderm type. The animal may pass from either of the first three forms into the Echinoderm, or may run through them all." See Ueb. d. Larven un. d Metamorph. d. Holoth. u. Ast. p. 33. See, also, a review of Muller's researches, by Huxley (Ann. Nat. Hist. VIII. 1851, p. 1), and by Darcet (Ann. d. Sc. Nat. XVII. 1852, p. 349).

These results are highly interesting in both a zoological and a physiological point of view, and I need only suggest their important relations to the doctrine of "alternation of generations."

In this connection, it may be proper to allude to another point. It is well known that Fogt (Naturgesch. d. lebend. u. untergegang. Thiere. I. Lider. 3, p. 251) has removed the Beroul Medusae from the Ancephae to the "Molluscoida," regarding them bilateral animals. In a private letter from Agassiz, there is a passage bearing directly on this point. He says: "The young Echinodermata are structurally and morphologically homologous with Beroul Medusae, showing that Beroul's are genuine Radiates, and truly belong to the class of Ancephae, and cannot be referred to the Molluscoids. These relations will be plain by comparing Taf. I. fig. 6, of Muller's Larven und d. Metamorph. d. Ophiuren und Seebigel. 1848, with the figures of P. VIII. of Agassiz' Memoir on the Beroul Medusae, in the Mem. of the Amer. Acad. of Arts and Sc. Vol. IV."

For further writings on the development of the Echinoderms, see Muller's papers, published in his Arch. 1843, p. 113; 1849, p. 54, 364; 1851, p. 1, 272, 359; but these papers are all included in his large memoirs already given. See, also, Krohn, Beitrag zur Entwicklungsgeschichte der Scyphidenlarven, 1849, and in Muller's Arch. 1851, p. 358, 344, 368; and Desor, Muller's Arch. 1849, p. 79.
BOOK FIFTH.

HELMINTHES.

CLASSIFICATION.

§ 99.

It is very difficult to characterize the class Helminthes, for it contains animals having widely dissimilar organization. On this account, the separation of its groups, and their distribution among the other classes of the invertebrata, has been attempted. But such various difficulties have arisen from this, that for the present, it is best that all these animals should remain together. If a common character is not furnished by their structure, it must be sought for in their manner of life; for nearly all are parasites, and during their whole life, or at least during some of its periods, seek their abode and nourishment in or upon other living animals.

ORDER I. CYSTICI.

The body is swollen in the form of a bladder, and filled with a serous liquid. Digestive and genital organs are wanting. Genera: Echinococcus, Coenurus, Cysticercus, Anthocephalus.

ORDER II. CESTODES.

The parenchymatous body is riband-like, having often incomplete transverse fissurations; often it is wholly divided transversely into rings. Digestive organs are wanting. The genital organs of both sexes are combined in the same individual, and generally are often repeated. Copulatory organs are present.

Genera: Gymnorchus, Tetrarhynchus, Bothriocephalus, Taenia, Triacanthophorus, Ligula, Caryophyllacus.

1 Anguillula is the only exception to this.
2 The head of the sexless Cystic, as to its form, its hook and suckers, strikingly resembles that of some Cestodes; from which it might be inferred that they are only the larval forms of these last.
ORDER III. TREMATODES.

The body is parenchymatous, and usually flattened. The intestinal canal, which is often branching, has a mouth, but nearly always is without an anus. The genital organs of both sexes are combined in the same individual. Copulatory organs are present.

Genera: Gyrodactybus, Axine, Octobothrium, Diplozoon, Polystomum, Aspidocotylus, Aspidogaster, Tristomum, Monostomum, Holostomum, Gasterostomum.*

ORDER IV. ACANTHOCEPHALI.

The sack-like body is flattened, transversely striated, and swollen cylindrically by the absorption of water. Digestive organs are wanting. The genital organs are situated in separate individuals. Copulatory organs are present.

Genus: Echinorhynchus.

ORDER V. GORDIACEI.

The body is filiform and cylindrical. The digestive organs are without an anus. The genital organs are situated upon separate individuals. Copulatory organs are sometimes present.

Genera: Gordius, Mermis.

ORDER VI. NEMATODES.

The body is sack-like and cylindrical. The digestive canal has a mouth and an anus, and passes in a straight line through the cavity of the body. The genital organs are situated upon separate individuals. Copulatory organs are present.

* In this connection, and especially in reference to the remarks made by the author under § 99, it may be well to notice that Pan Beneden does not regard the Linguatulae as true Helminthes, but that they belong rather to the division of articulated animals,—coming nearest to the Lerneae. His reasons are the following:

These animals, on their extrication from the egg, are provided with two pairs of articulated feet terminated by hooks.

The nervous system differs from that of the Lerneae only in having two cords which form the ganglionic chain, separated throughout their whole length, whilst in the Lerneae they are separated for only half their length.

In both cases the males are comparatively very small. The ovaries of the females are equally bulky; but in the Lerneae which live in water they project externally, whilst in the Linguatulae, which always live in a different medium, they remain in the interior.

* Besides the ring of nerves, the sub-oesophageal ganglion, and the cords which represent the ganglionic chain, the Linguatulae are provided with different ganglia representing the great sympathetic. I detected four perfectly distinct ganglia spread over the sides of the lower surface of the oesophagus in the new species from the Mandrill. In another species M. Blanchard detected these ganglia and stemato-gastric nerves; but he referred them to the system of the nerves of relation or those of animal life, judging, at least, from the name which he has assigned to them.

Another point, which, however, had not escaped the attention of naturalists, is that the muscles exhibit in their primitive fibres the transverse lines which are not met with in the lower animals.

See Bull. de l'Acad. Royale de Belgique, 1848, XV. No. 2. See also Blanchard, Comp. Recal. 1856, XXXI. p. 629. — Ed.

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Bojanus. Enthelminthica, in the Isis, 1821, p. 162.

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Creplin. In the same work, articles: Distomum, Echinococcus, Echinorhynchus, Eingeweidewürmer, Enthelminthologie, &c.


E. Schmalz. XXIX. Tabulæ Anatomiam Entozoorum illustrantes. Dresdae, 1831. These contain mostly copies.

C. Th. E. Siebold. Helminthologische Beiträge und Jahresberichte über die Helminthen, in Wiegmann's Arch. für Naturgeschichte.

Diesing. His excellent Monographs in the Annalen des Wiener Museums.


R. Owen. His excellent article, Entozoa, in the Cyclopaedia of Anatomy and Physiology.

§ 100. THE HELMINTHES.

ADDITIONAL BIBLIOGRAPHY.

The following are among the more important contributions to the Anatomy of the Helminthes which have been published since the issue of the original work. I should mention, however, that I have not had very much access to recent German contributions in this department, from the tardiness with which such matters reach this country. However, I am happy in not being ignorant of the late publications of Siebold, who is truly at the head of Helminthology.


Note sur le developpement des Tétrarhyques, in the Bull. de l'Acad. de Belgique, XVI. 1849.

Recherches sur les Vers Cestodes, in the Mém. de l'Acad. de Belgique, 1850, XXV.


Ueber die Verwandlung des Cysticercus pisiformis in Taenia serrata. Ibid. IV. p. 400.


See, also, various valuable though small contributions, in the form of letters to Siebold, in Siebold and Kölliker's Zeitsch. IV. p. 52, 116, 451, 454; as well as the references in my notes.—Ed.

CHAPTER I.

CUTANEOUS SYSTEM.

§ 100.

The body of the Helminthes is generally surrounded by a firm skin, which may be separated into a thin epidermis, and a pretty hard dermis. The epidermis of the adults is never ciliated; but not unfrequently it has horny spines pointing backwards, which sometimes are limited to the anterior part of the body, and sometimes spread over a large surface, in transversely serrated rows. (1) In the first case, the spines serve to attach them

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(1) In many Nematodes, Acanthocephali, and Trematodes, the epidermis is spiny like a rasp. These spines are simple in Lisorhyncha denticulatus, Lecanoecephalus spinatum (according to Diesing, Annalen des Wiener Museums, II. Abth. 2, 1830, Taf. XIV. fig. 14-20), Echinorhyncha pyriformis, and hystrix (Bremser, Icon. Helminth. Tab. VII.), Distomum tinea, macula-
THE HELMINTHES. § 101.

to other animals, and therefore will be specially described with the locomotive organs.

With most of the Nematodes, the epidermis has very fine and closely approximated transverse folds, which are but occasionally so prominent that the body appears annulata.(2) Sometimes, but rarely, the body is also plicated in a longitudinal manner.(3) The dermis has a fibrous structure, consisting of two fibrous layers,—one longitudinal and the other transverse,—which cross each other at right angles; and of two other layers, which intersect each other more acutely.(4) The skin of these animals has a great absorptive power which during life is voluntary, but which continues to a certain extent after death, so that then these worms often swell enormously, and sometimes burst.(5)

§ 101.

Directly beneath the skin of the Cystie, and Cestodes, are found hard corpuscles containing carbonate of lime, and which may be regarded as the vestige of a cutaneous skeleton. But, as they are scattered here and there more deeply in the parenchyma, they certainly may be compared to the spicula and calcareous net-works found in the skin of many Polyps and Echinodermns. Oval or discoid, they are usually of equal size in the same individual. Sometimes, however, they present irregular and unequal forms. Always colorless and transparent, and composed of concentric layers, they refract the light like small vitreous bodies.

In Taenia, Tricenophorus, Bothriocephalus, and the young of Echinococcus, they are subcutaneous, and more or less scattered; but in the wrinkled and vesicular body of Coenurus, and Cysticercus, they are so very abundant that they form quite thick layers. They are absent in the caudal vesicle of Cysticercus, but in Coenurus, and Echinococcus, they are found in the vesicular walls beneath the delicate epithelium which lines the interior of the body.(3)

2 This is so, for instance, with the anterior extremity of Librahyxus decinflatatus, and Strongylus annulatus, mili (from the trachea of the wolf).

The epidermis of Ascaris nigrovenosa has such long and loose folds that its body, seen laterally, has a fringed appearance.

3 Excluding the longitudinal folds of the epidermis, which form lateral wings of variable form and length at the cephalic extremity of the Nematoidea, or on both sides of the extremity of the tail of many males of this order (Bremer, Icon. Helminth. Tab. IV. fig. 22-24). I have as yet found the epidermis longitudinally plicated over the whole body only with Strongylus striatus, and infectus.

4 These different dermal layers are distinct, especially with Gordius and Mirinae; see Infusorina's figure in the Am. d. Sc. Nat. XVIII. 3612, Pl. VI. I have found this structure also in Ascaris megastas, microcephala, Dictyum echinatum, hians, laticauda, and in Monostomum verrucosum.

In Amphistomum zicventum, Diesing (Annal. d. Wiener Museums. 1. Athl. 2, p. 239, Tab. XXII. figs. 1, 3, 4), has regarded these layers as mucous. The same is true of Bojournia (1831, 1832, p. 166, Tab. II. fig. 12), and Lower (De Amphistomato conditi, p. 6, fig. 10).

But the structure of the skin of Echinococcus is quite different. Here no epidermis can be separated from the dermis or the skin of the body; and the whole is a thick membrane, resembling conglutinated albumen and composed of numerous very thin layers, tightly bound together.

5 This absorptive power of the skin is particularly prominent with the Acanthocephali. It is here really a vital act; for Echinoacanthus, which naturally absorbs only a little liquid into its constantly flattened and wrinkled body, swells and relaxes alternately when in contact with water. This has been observed with many species by Creplin (Nov. Observ. de Entozoa. 1829, p. 44, and in Erich and Goeze's Encyclopaedia XXX. 1838, p. 334), by Mebius (1831, 1832, p. 167), and by myself. With the Nematoidea it is otherwise. These cannot voluntarily govern this absorbing power, and when, therefore, they are put in water, they swell to bursting and die. With the Gordiida this power is purely physical, so that the dead and dried individuals of Gordius aquatilis, when placed in water, quickly become round again, and perform very active hydroscopic motions.

These calcareous corpuscles, which are always without an envelope and are scattered through the whole body of these Helminthes, have been taken by Pallas, Goeze, Zeder, and by most Helminthologists until lately, for eggs, and as such were often figured.
CHAPTER II.

MUSCULAR SYSTEM AND ORGANS OF LOCOMOTION.

§ 102.

The muscular system is well developed with the Helminthes; its primitive fibres are flattened, and never transversely striated. In the Cysticid, and Cestodes, the muscles are least distinct, although in Cysticercus there can be no question as to the muscular fibres which traverse in every direction the walls of the caudal vesicle. (1) Equally distinct is a subcutaneous layer of longitudinal fibres in the rings of Bothriocephalus and Taenia. (2) Moreover from the great contractility of the rings, and especially those of the cephalic portion of the Cysticid and Cestodes, there must be muscular fibres concealed in the parenchyma, but which from their tenuity escape our observation. In the Trematodes, having also an extreme contractility, a large portion of the parenchyma of the body is composed of a muscular reticulated tissue, the transverse and longitudinal muscles of which embrace the various organs in a retiform manner. (3) In the Acanthocephali, the Gordiacei, and Nematodes, the general movements of the body are due to a subcutaneous muscular layer, which surrounds the visceral cavity in a sac-like manner. Its longitudinal and transverse muscles are quite distinct from each other; and their fibres, although parallel, communicate with each other by angular anastomoses, and in this way form a net-work. (4)

In most of the Nematodes, the longitudinal muscles form four, large bands, two upon the ventral, and two upon the dorsal surface. These

In the Cestodes, this error is unnecessary, for in the posterior portions of their body the eggs can easily be distinguished from the corpuscles; moreover, these latter are the most numerous about the neck and anterior rings,—localities where the genital organs are scarcely and sometimes not at all developed. It may be added, also, that these bodies dissolve in a weak acid with the escape of gas, while the eggs of Taenia under the same circumstances remain unaffected. In the Cystid, which are ascidians, and where therefore eggs are vainly sought for, these corpuscles, as to their structure, chemical composition, and position, so closely resemble those of the Cestodes, that it appears strange that they have always been taken for eggs. Eschricht (Nov. Act. Acad. Leopold Carol. Vol. XIX. Suppl. alter. 1841, p. 99, 100), not having perceived that they contain carbonate of lime, has described them as elementary granules, and thinks that they have a nutritive function analogous to that of the blood and lymph corpuscles.

Gulliver (Med.-Chir. Trans. Vl. London, 1841, p. 132) and Wiemauer's Arch. 1841, II. p. 234) has given an exact description of those of Cysticercus, but he also has taken them for eggs. In Taenia fiaches, lioei, serrata, and enfundibuliformis, they are spherical or oval; and in the first two species, Goeze (Versuch einer Naturgesch. d. Königswieswurmer, p. 399, Taf. XXXII. A. fig. 6, 7, 12) has taken them for eggs, and the concentric rings of the calcareous layers for the coils of the embryo. With those of Cysticercus celtoides, and postiformis, the discoid form prevails; I have often seen here to six calcareous layers about the nucleus; and sometimes there are two nuclei thus enclosed, and then the corpuscles have exactly the aspect of the precious stones of Isisara.

Those of Taenia cuscinervae, bothriocephalus solidus, and Cysticercus fasciolaris, are usually of an oval form, sometimes irregular, and of a variable size. Tachulis (Die Blasewurmser, 1857, p. 24, Taf. II. fig. 21) has figured those of the last species as eggs.

1 I have easily seen these muscular fibres in the caudal vesicle of Cysticercus celtoides, and tennumcollis. But they are wholly absent in the parent-vesicle of Echinococcus hominis, and ceticineorum. This vesicle, therefore, has probably no spontaneous movements, whilst the embryos it contains at certain times have distinct locomotive organs.

2 The longitudinal fibres of the subcutaneous muscular layer, have been observed in Bothriocephalus latus, by Eschricht (loc. cit. p. 55) and in Taenia amelasta, lanceolata, nasuta, and villosa, by myself.

3 In the reticulated muscular parenchyma of the Trematodes (Amphistomum zigzagium) has been represented by Diessing very beautifully (Ann. d. Wiener Museums I. Abth. 2, Taf. X. fig. 8-6).

4 In Ascaris lumbricoides, as in most Nematodes, the muscular fibres are so closely approximated that the meshes of their net-work are not seen except by tearing asunder the muscles; see Bojanus, Isis 1821, Taf. III. fig. 48. The reticulated form of the longitudinal muscles is very distinct in Cestodes and gracilis; see Diessing, Annal. d. Wiener Museums, II. Hft. 2, p. 235, Taf. XVII. fig. 1, 2.
bands are separated by the same number of longitudinal lines, the two narrowest of which are above and below; while the others, which are large and riband-like, are on the sides.\(^5\)

In the Acanthocephali the transverse muscles are more superficial than the longitudinal,\(^6\) while in the Nematoles and Gordiacei the inverse is true.\(^7\)

\[\text{§ 103.}\]

There are with the Helminthes a great variety of organs for the movements of the body. With the Cystici, Cestodes, and the Trematodes, there are often sucking-cups and cavities; the first of these are more or less alveolate, being formed of numerous layers of circular and radiated muscular fibres,\(^8\) while the second are only excavations in contractile parenchyma of the body, and are divided into many chambers by septa, or have very variable lobular appendages.\(^9\) Many of these suctorial organs have, — some at their bottom, others on their borders, hooks with a horny support, by which these animals can firmly attach themselves to objects.\(^10\)

\(^5\) Bopansa. Ibis, 1821, p. 186, Taf. Ill. fig. 45, 46. Ascaris lumbricoides, Polystoma amphibium, Polyactis amphibii, Acanthocephali, etc.

\(^6\) In Acanthocephali the transverse muscles intercommunicate with each other by short and narrow anastomoses, and form a complete ring, which surrounds the longitudinal ones like a large girdleless, in reference to this, Echinorhynchus gigas. In Echinorhynchus zibboue these anastomoses have been found only above the swelling of the body.

\(^7\) The transverse muscular bundles of the Nematoles, which are not as closely united as the longitudinal ones, do not form closed rings, but produce four strong, which are separated from each other by the crossing over of the longitudinal muscles. At least, this is so in Ascaris lumbricoides, Stron- gyulus gigas, and most of the species of this order. Bopansa (Ibis, 1821, p. 187, Taf. Ill. fig. 51, 54) and Clonchpt (Ann. et Mem. d'Agassiz, 1855, Taf. II. fig. 3) have taken these transverse muscles for vessels; and Dising has made the same mistake with the muscular bands of Chirocephalus and Angiostoma (Ann. d. Wiesen, Muscum 11, Abibb. 2, Taf. XVI. fig. 1, and 2, Taf. XVIII. fig. 2).

\(^8\) In Ascaris inflata, and Flora alternata. I have seen the transverse muscles turned in the same manner. In Ascaris serpentensis they have a peculiarity; their more or less long fibres pass off from the longitudinal muscles at a right angle, and are inserted into one or the other of the two narrow longitudinal rays. In the Gordiacei, the longitudinal layer is not broken by any ray of this kind, but forms continuous tubes which have thin walls and a suctorial aspect, and where the flattened and riband-like fibres are bound together by their faces, and at the same time anastomose with each other.

\(^9\) This would at least appear to be so, judging from the net-work with long muscles which is produced by a little traction. I have not found the transverse muscles in Gordius; but in Merismoneuropterus, there is, under the longitudinal muscular layer, a net-work like the preceding, but with very large meshes. Dejardin appears to have observed it, but he remarks that it is not connected with the openings of this worm (Ann. d. Sc. Nat. XVIII. 1842, pl. VII. fol. 10).

\(^10\) The young Echinococcus, the Corontus, Cystidicola, and Tavine, have usually upon the cephalic extremity four imperforate cup-like cavities, which can serve only as suckers. It must have been observed of Vicedor Ericsch and Gruber's Encyclopedi XII. 1824, p. 99) who regarded these in Tavine as so many oral orifices leading into the alimentary canal. It is only with Distomum, Angiostoma, Polyactis, and other Trematodes, that this sucker, which is situated in front, is perforated at its bottom, and serves also the function of mouth.

The ventral sucker of Distomum, and that found at the posterior extremity of Angiostoma and Polyactum, as well as the numerous analognous organs upon the bands of Monactum, etc., and upon the terminal dilatation of Angiostoma mutabilis (Dising, Ann. d. Wiesen Muscum 11, Abibb. 2, p. 244, Taf. XV), are all imperfecto. That upon the posterior extremity of Angiostoma subtercecum, anguillacaudum, is remarkably; it has a small dilatation at its back, which Dising (loc. cit. I. Abibb. 2, p. 291, Taf. XXIV) has erroneously regarded as the opening of the rectal organs. In Polyactum, five large suckers pass from the interior of the body, and are spread upon the convex surfaces as many suckers, situated at the posterior extremity, and which they properly move during the animal's creeping.

Upon the head of Bothriocephalus, Tetra- rhynchus, and Anchrocephalus, there are two to four simple cup-like holes with Distomum, Polyactum, and some other Trematodes, there are two on each side of the mouth, and with Leburo, Octostomum, and others, there are two which are subseeved and behind the mouth.

With Bothriocephalus truncatus (Bervence, loc. Helm. Tab. XIII, fig. 23, or Leburo, Zool. Bruchstücke. Ht. I. Taf. fig. 4, 5), there are four, which are divided into chambers by many septa and with Jaspeocephalus (Bervence, N. Art. Acad. Log. Carol. Vol. XIII. 2, Tab. XXIV), the whole ventral disc is divided by septa into quadrangular suctorial fasci. The head of Bothrio- cephalus auriculatus has a singular aspect, due to numerous partly crenulated lobes, which form four suckers (Bervence, loc. cit. Taf. XIII. fig. 17, 18, and Leburo, loc. cit. Taf. I. fig. 6, 13, 14). A very simple structure is found upon the head of Bothriocephalus trilocularis, and (from the introduction of the suckers) here the points of junction of the fasci are prolonged into four triangular lobes, by which the animal can adhere tightly to its object. Holostomum, which lives in the intestines of birds and mammals, has analogous appendages around the cavity which is situated at the anterior extremity, and which it fastens to the intestinal villous: see Dising, in Leburo, and Gruber's Encyclopedi III. p. 299, IX. 1822, fig. 1.

\(^3\) This condition of things is found especially in
The young of *Echinococcus*, *Coenurus*, *Cysticercus*, and many of the *Taenia*, have their head armed with a circle of single or double hooks, which were known to the oldest Helminthologists. Each hook consists of a strongly-curved point, situated upon a round, straight pedicle, of variable length. At the point where the curve ceases, there is, upon the concave side of the organ, a small conical process. When this circle of hooks is unfolded, the points project around the anterior part of the head, whilst the pedicles point towards the inner and their processes towards the posterior portion of the body, and are buried in the parenchyma. Both are surrounded by muscular substance. When, therefore, the muscles of the pedicles contract, the hooks are drawn downwards and outwards, and their points are brought together upon their convex surface in the long axis of the head; but when, on the other hand, the muscles of the processes contract, these last are depressed, the pedicles are again elevated, and the hooks project outward. With many Cestodes, this circle of hooks is situated upon a particular proboscis (rostellum), which can be retracted into a sheath which is concealed between the four suckers of the head.\(^4\)

With *Anthocephalus*, *Gymnorchus*, and *Tetrarhynchus*, there are upon the head four long and completely retractile proboscises, which are armed with an extraordinary number of small, backwardly-curved hooks which are attached by a large base to the external surface of the organ, and are without special muscles; by these, these animals can penetrate the most compact animal tissues. Each proboscis is a hollow muscular tube, which can be voluntarily retracted within a sheath of the same nature, and then the hooks, with their points directed in front, are drawn together in its axis. The length of the sheath, which is usually enlarged at its base, depends upon that of the proboscis. In many species of *Tetrarhynchus*, they reach far into the neck of the animal.\(^5\)

The Acanthocephali have only one of these organs, and the hooks, which are without special muscles, form rows arranged one after another. Both the number of these rows and the form of the hooks vary in different species. Usually their size decreases from before backwards, so that those

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\(^4\) With *Echinococcus*, *Coenurus*, and *Cysticercus*, the number of hooks is twenty to thirty; and I have seen as many with *Taenia scolicida*, and *infundibuliformis*; but I have found only eighteen with *Taenia aculeata*, ten with *Taenia setigera*, and eight with *Taenia taceolata*.

\(^5\) With *Taenia*, and especially those which have these organs on the proboscis, they may be partly or even wholly detached. Rudolphi has regarded *Taenia crassicollis*, *aculeata*, *infundibuliformis*, *setigera*, and *stylosa*, as naturally without these organs, but I have often found them having a complete circle.

With *Taenia cecumida*, the structure is different; its seven rows of hooks are in all respects like those of *Echinococcus*.

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of the last row are only rudimentary. The sheath of the proboscis is very muscular, and terminates behind in a caecum; it extends across the neck of the animal even into the cavity of the body, and its movements are aided by some special muscles. In all the species whatever, there are three muscles which act as retractors of the sheath and neck. Two of these arise as delicate cords at the anterior extremity of the body from both sides of the internal surface of the subcutaneous muscular sac; they traverse thence the cavity of the body obliquely, and are inserted in *Echinorhynchus acus*, *anguistatus*, *fusiformis*, and *protus*, upon the sides of the sheath; but in *Echinorhynchus gigas*, *haeruca*, *polymorphus*, *hystrix*, and *strumosus*, the insertion is at its inferior extremity. Between these two muscles, and below their points of origin, there is a third, which divides from the subcutaneous muscular sac; this is simple, riband-like, and is inserted at the lower extremity of the sheath. In *Echinorhynchus polymorphus*, and *protus*, its form is pyramidal. In *Echinorhynchus gigas*, and *gibbosus*, two thin muscles arise from the anterior extremity of the body, and are inserted upon the sides of the sheath; they serve, probably, for the protrusion of this organ and the neck.\(^6\)

There are, moreover, upon the different parts of the body of some Helminthes, horny hooks and spines, which serve for their creeping about and permanent attachment to objects.\(^7\)

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**CHAPTER III.**

**NERVOUS SYSTEM.**

\(\S\) **104.**

The apparently quite feebly-developed nervous system of the Helminthes is yet but very incompletely known.

Our whole knowledge is limited to that of a small obscure ganglion found in some species, which, as it sends off several nerves, may be regarded as a sting which projects from the back above the oral sucker (and not from the mouth itself, as Wagner has supposed, Isis, 1834, p. 191), and which serves to open a passage through the peritoneum of the animals they infest. An entire group of Distomum, as Distomum echinatum, militare, uncinatum (Bremser, Icon. Helmint., Tab. X. fig. 5), which *Redolphi* has designated as Echinostoma, have around their oral sucker an annular collar, upon which are numerous straight spines arranged in a circular manner. An armature of this kind is found upon a Cercaria. These spines are as easily detached as the hooks of the armed *Taeiae*. With *Spiroptera crassicauda*, I have found on each side of the mouth a doubly-pointed sting pointing backwards, and behind this two others three-pointed. A still more remarkable form is seen in the four peniform stings, which project behind the mouth of *Ancycocautus phasmatidis* (see Diesing, Ann. d. Wiener Mus. H. Abt. 2, Tab. XIV. XVIII). These Nematodes undoubtedly use these instruments for piercing the stomodeal membranes of the animals they infest.

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\(\footnote{6}{Helminthologists are not yet agreed as to the number and arrangement of the proboscidal muscles of the Acanthocephali; see Nitzsch, in Erzeh and Gruber's Encyclop. I. 1818, p. 242; Dujonius, in Isis, 1821, Taf. III. fig. 34; Westrum, De Helminthibus Acanthcephali 1821, p. 50; and Cloynet, Amst. des Ver. Intestin. p. 75, Pl. VII. Mehlis (Isis 1831, p. 82) has taken the proboscidal sheath for an exoskeletal organ, and its two muscles for vessels. Darom (Echinorhynchus strumosus) Auzoue, 1836, p. 16, fig. 1, c) has fallen into a similar error, in regarding these same muscles as intestinal tubes.}

\(\footnote{7}{With many Trematodes, as, for example, with *Polystomum*, *Octobothrium*, &c. (see Pier, Nov. Act. Acad. Leip. Cir. XIII. p. 2; Tab. XXIII, fig. 7, l. and Mayer, Beitræge, &c., Taf. III. fig. 3, m. m. fig. 8), there are found between the suckers at the posterior extremity, special hooks, and to which, with *Polystomum*, I have seen proper muscles proceed from the interior of the body. With certain *Cercariae* (form of *Distomum*) one can distinctly observe the use which they make of this organ and the neck.}
§ 104. THE HELMINTHES. 109

a central nervous organ. There are, however, various other parts which have been taken for nerves, but some of these, certainly, do not belong to this system.

In the Cysticci, no nervous system has yet been found, and the researches made upon the Cestodes have ended equally unsatisfactorily. A single observation upon a Tetrahymenacus would lead us to think that in these last the nervous system is situated at the cephalic extremity.

In Tetrahymenacus attenuatus, there is a small flattened swelling between the sheaths of the four proboscides, and from which pass off filaments to both of these organs.¹

The observations upon the nervous system of the Trematodes are more numerous and positive. Immediately behind the oral sucker, and upon the sides of the oesophagus, are two nervous swellings, connected by a transverse cord, which passes beneath this canal. Among the branches given off in all directions from these, there are two, large and long, extending from each side of the body to its extremity, and which give off in their course many lateral branchlets.²

In Pentastomum, the central portion of this system consists of a single large ganglion, sub-oesophageal, and due perhaps to the fusion of two lateral ganglia. From this, filaments pass off in every direction; two of these surround the oesophagus in a ring-like manner, while two others, analogues of the two main trunks of the Trematodes, pass to the very extremity of the body, giving off on their way, very fine filaments.³

¹ Müller, not without reason, regards this organ as the nervous system of Tetrahymenacus (Arch. 1836, p. CVL.). New observations are needed to decide if, as Lacroix (Institut. 1839, No. 382, p. 118) supposed, there can be included in this system the two longitudinal stripes, which, with Liggula simplicicosta, extend along both sides of the ventral surface, and from which, at least, have been pass no filaments.⁴

² Our very exact knowledge of the nervous system of Amphistomum subostricum, and conicum, and of Distomum hepaticum, we owe to the researches of Boeunus (Isis 1823, p. 106, Tab. II. fig. 14, 15, 19), of Lauer (In Amphistomum conico., p. 12, fig. 21, 22), and of Melchis (In Distomate hepatico, p. 22, fig. 15).

By continuing the methods of these lemmatologists, this system will undoubtedly be found in other Trematodes. Diesing (Ann. d. Wiener Mus. I. Abth. 2, p. 246, Tab. XII. fig. 9) has found in Amphistomum giganteum, and I have done the same in Distomum duplicatum (which is properly only a larva of a species of this genus) the same disposition noticed in Amphistomum conicum.

³ Miram (Nov. Act. Acad. XVII. pt. 2, p. 632. Tab. XXVI. fig. 5) did not, apparently, notice in Pentastomum taenioides the nervous ring which surrounds the oesophagus; although it had already been noticed by Cuvier (Règne Anim. III. 1830, p. 251), and by Nordmann, in a work in common with Melchis (Miscr. Delit. Hist. 2, p. 141). The existence of this ring has been placed beyond a doubt by the figures of it as found in Pentastomum taenioides, and proboscideus, given by Owen (Trans. of the Zool. Soc. I. p. 329, Pl. XI. fig. 13), or Cyclops, Ant. and Phys. II. p. 150, fig. 78), and Diesing (Ann. d. Wiener Mus. I. Abth. 1, p. 13, Tab. I. II.).

He says: "I believe the nervous system described by Blanchard to be bands of muscular fibres which cross each other between the fossae of the proboscis: at least, this is so in the new species of Taenia from Amin catuca which was observed alive for several hours; and I could discover no nervous threads, but only muscular fibres, which had exactly the arrangement of Blanchard's nervous system."

See, however, Valenciennes' report to the Acad. des Sc. in the Compt. rend. 1847, XXIV. p. 1064, also Blanchard's response to Linjerard, Bull. 1849, XXIX. p. 60.—En.

⁵ [§ 104, note 3.] Blanchard has found with Lingualata another ganglion above the oesoph-
The central nervous system of the Acanthocephali is very distinct. It is always concealed at the bottom of the sheath of the probosces, which this last, being never in a state of complete retraction, does not fill. It consists of a dense mass of ganglionic, cellular globules blended together, and here and there may be seen through the cell-membranes their nuclei and corpuscles. This comparatively large mass sends off nerves in every direction, but the tenacity of these prevents their being traced, especially after they have entered the muscular walls of the proboscidial sheath.

With the Gordiacea, and Nematodes, a nervous system has been found with certainty only in Strongylus gigas. Here a cord arises from a swelling in the head, traverses the whole length of the body upon the median ventral line, and terminates at the posterior end of the body in another swelling. It sends off in its course lateral filaments, thus resembling the nervous system of the Sipunculidae.

4 I have thus found the nervous system of the Acanthocephali in Echinorhynchus gigas, angustatus, hermicos, and probosces. It can be easily observed by carefully pressing or tearing the proboscidial sheath. In thus tearing, you sometimes completely expose the ganglionic mass with the roots of the nerves. In no species that I have dissected have I been able to find the ganglionic ring mentioned by Heute (Protopl. neue Nat. No. 258, p. 350, and Matta's Arch. 1846, p. 318) as found about the genital orifice of Echinorhynchus nodosus.

Dujardin also (Hist. Nat. d. Helm. p. 495, 497, Pl. VII. fig. D. 4), has not observed it, but he distinctly perceived the central mass at the base of the probosces, and has figured and named it as a corpus glandulare on ganglionaire.

5 As yet no nervous system has been found in the Gordiacea. Birthold (Uber den Bau des Gordius aquaticus, 1842, p. 12) has been inclined to regard as nerves two delicate filaments which traverse the cavity of the body of Gordius; but, as these give off no lateral branches, this opinion cannot be admitted.

6 Many Helminthologists have erroneously taken for nerves the delicate projecting lines which, situating directly subcutaneous and often blended with the skin, traverse the whole length of the body of many Nematodes, and have been called the ventral and dorsal lines. Their lateral branches, as already observed, are only transverse muscular bands. Quite different from these is the longitudinal cord, which Otto (Magaz. d. Gesell. naturf. Freunde zu Berlin, 7th Jahrb. 1816, p. 225, Taf. V.) has described and figured as belonging to the nervous system; a view which I am disposed to adopt, in spite of Nitzsch (Ersch and Grauber's Encyclop. VI. 1821, p. 49) and other Helminthologists.

In a large female Strongylus gigas, now under my eyes, there is a simple longitudinal cord beneath the muscular envelope, and therefore in direct connexion with the skin, and which extends along the ventral surface. In its course it sends off numberless lateral branches, which in their intimate structure are quite different from the transverse muscular bands. But neither here nor upon the nerves of other worms have I ever seen the enlargements spoken of by Otto. Grant's figure of a double nervous filament traversing the body of Ascaris is probably imaginary; see Outlines of Comp. Anat. p. 186, fig. 82, A.

gus, which he regards as a brain; these observations have since been confirmed by Van Beneden (Ann. d. Sc. Nat. XI. 1849, p. 319) who, however, regards this mass as belonging to the sympathetic system. But, however viewed, an osophageal collar has been distinctly made out, thus confirming the views ofments. In regard to the osophageal system of nerves with these animals, Van Beneden (loc. cit.) describes it as consisting of two ganglia lying on the oesophagus back of the osophageal collar, and from which pass off two filaments, which run along the oesophagus, and enter the collar laterally. He thinks the two ganglia are united by a transverse commissure. Further behind is another and larger ganglion on each side, and from which pass filaments to the digestive cavity. See also my note under § 99.

* [§ 104, note 5.] This view of Berthold is supported also by Blanchard (Ann. d. Sc. Nat. 1849, XII. p. 6), who affirms that he has observed on both sides of the body a double longitudinal cord, which is usually very distinct. This, examined microscopically, appeared to be composed of the nerves of the other Helminthes. Blanchard, however, did not succeed in tracing these cords to any cephalic centres. Nothing of special value, therefore, is known on this subject. — Ed.
CHAPTER IV.

ORGANS OF SENSE.

§ 105.

The sense of touch is probably the only one well developed with the Helminthes. The granulations, warts, papillae, filaments, and retractile lobes, found upon the head of some species, are, without doubt, the organs of this function. The red and black points upon the back of many, both adults and larvae, and which have been regarded by some naturalists as organs of vision, appear to be only pigmentary spots; for they contain nothing like a light-refracting body.

CHAPTER V.

DIGESTIVE APPARATUS.

§ 106.

The digestive organs with the Helminthes have a variable degree of development in the different orders.

In the Cysticci, Cestodes, and Acanthocephali, neither mouth nor alimentary canal is perceived. In the first two orders, there is, however, a system of vessels which may be regarded as a digestive apparatus; but these are designed for circulation, rather than for digestion, since their walls are complete throughout and have no openings, as has erroneously been supposed, which communicate with the suckers of the head; and their contained nutritive material is received by them through the skin in an endosmotic manner.

1 These tactile granulations are found with many species of Ascaris, as, for instance, in Ascaris osculata, between the large oral collars; in Physa-lopiera aloita, they surround the oral extremity of the body as a single row; but they form a double one in Ascaris trunciolata. With Distomum ?aurocaecum, and nodulatum, they are found upon the borders of the oral sucker. With Holostomum excenatum, and podospermum, there are two retractile lobes protruding from the sides of the mouth; and in Holostomum alatum, these have antenna-like filaments; see Nitsch's figures of Holostomum, in Ehrich and Gruber's Encyklopa. III. p. 309, IX.

2 These dark pigment-dots upon the infusoria-organ of many Trematodes when they escape from the egg, and of which there is only one upon the neck of Distomum nodulatum, and kias, and two upon Monostomum mutabile, have been taken for eyes by Nordmann (Beitr. Infusorienkunde, p. 29, Taf. 1.) has described in Cercaria ephemeris; 1 have seen only two upon the back of many cercarian larvae. Of this same nature are the two red dots of Scolex poly- morphus (Muller, Zool. Pal. Tab. LVIII. fig. 16, 17), as also the brown ones upon the neck of Gyrodactylus avriculatus (Nordmann, Micr. Beitr. Hft. 1. p. 108, Taf. 12). Finally there may be mentioned Amphistomum subhastatum, which has two large oval black dots upon its neck. These pigment-dots are physiologically, with at doubt, simply colored spots, which in Poly stomum integerrimum are highly developed, forming a widely-spread subcutaneous net-work. Sometimes, and especially in the various Cerca rias, and in many individuals of Amphistomum subhastatum, these dots have a very effaced aspect; this is probably due to a dissolution of the walls of the cells,—the pigment-granules being then scattered through the skin.

1 It has already been observed that the four suckers of Taenia, regarded by Nitsch as oral orifices, are imperfect at their bottom. Owen (Cyclop. Anat. &c. II. p. 133) has fallen !
The food enters the cavity of the body of *Echinorhynchus* probably in the same manner, for their skin has great power of absorption.\(^3\)

The Acanthocephali have this peculiarity, that between the skin and the muscular walls of the cavity of the body there is a thin layer of finely-granulated parenchyma, often of an orange or yellow color, which is traversed by longitudinal and transverse canals.

These canals, having no proper walls, form a continued vascular system, and contain a liquid-filled with granules and vesicles. As this system is completely closed, and cannot therefore receive nutritive substances from without, it must be regarded as nutritive or circulatory, and not digestive, as it has been by many naturalists.

\(\text{§ 107.}\)

In the other groups of the Helminthes the digestive organs are pretty generally well developed.

The Trematodes have a mouth situated usually upon the border of the cephalic extremity, and where there is a sucker occupying its bottom. From this there passes along the middle line of the neck a thin-walled oesophagus, which is often of an S-like form. Directly behind the mouth or oral sucker, but sometimes a short distance removed from it, the oesophagus is surrounded by a round or oval muscular pharynx.\(^1\)

From the extremity of this pass off, usually, two blind intestinal tubes, which, passing along both sides of the body, extend generally to its posterior extremity.\(^2\)

The other forms of the digestive canal are as follows: in *Monostomum mutilabile*,\(^2\) and *flavum*, the two intestinal tubes, instead of ending coeally, form the arc of a circle;\(^3\) in *Aepidogaster*, a simple and uniform intestine succeeds upon the pharynx, and ends in a coecum at the posterior extremity of the body;\(^4\) in *Gasterostomum fimбриatum*, this canal is very short, and terminates in the same way, but there is a mouth in the middle of the ventral surface; in *Bucephalus polymorphus*,\(^6\) the structure is similar; and in *Pentastomum*,

similar error in regarding these organs as mouths, not only in *Taenia* and *Cysticercus*, but also in *Bothriocephalus*. I have been unable to find a mouth upon the cephalic extremity of the Cestodes, as has Mehlis (1st, 1831, p. 121), or upon that of *Taenia solium*, as has Owen (loc. cit. on the Comp. Anat. &c. p. 48, fig. 21, a.). The few sometimes found upon this last, is due to the extrusion of the circle of hooks, or of the proboscis, within the sheath.

1 Most Helminthologists admit that *Echinorhynchus* receives its food through a small orifice at the extremity of the proboscis, the sheath of the last adding in motion and digestion. I have been unable to convince myself of the existence of this orifice, and never have seen food in the cavity of the sheath. On the other hand, I have often, like Creplin and Mehlis, seen *Echinorhynchus* receive and expel liquids through the skin.

2 In *Distomum glomeratum*, the pharynx is somewhat removed from the oral sucker: see Barreis, in Wiesmanns Arch. 1835, II. fig. 1, 3. In *Distomum echinatum*, military and allied species, the oesophagus is usually very long. But in *Distomum oxycephalum*, it is very short; and in *Distomum appendiculatum*, it is entirely wanting, and consequently the intestinal bifurcation is directly behind the pharynx.

3 In *Monostomum*, *Amphistomum*, *Holostomum*, *Distomum*, and *Polystomum*, the intestinal bifurcation extends to the posterior extremity of the body. With *Distomum chilostomum*, and many other species of this genus living in the Neotropic, the whole intestine is reduced to two short right and left coeca, which are given off from the end of the oesophagus.

4 *Creplin*, Nov. Observ. de Entozoz, fig. 10, 11.

5 This arrangement has been also, but erroneously, assigned to *Distomum terectilis*; see *Huguer*, Lehrbuch der vergleichenden Anat. 1834, p. 75, and Creplin, in *Erzehr* and *Gruber's Encyclopedia*, 934, p. 314.

6 This error is probably due to the inaccurate copying of figures; see Anat. d. Sc. Nat. F. 3, 1824, p. 406, Plat. XXIII. fig. 4, 5; and Schmaltz, Tabulae Anat. Entozoz. Tab. XIII. fig. 2, 3. By referring to the original figure in the *Memoir de Jurine* (Mem. de la Soc. de Phys. et d'Hist. Nat. de Geneve, II. pt. 1, 1832, p. 149, fig. 4, 5), from which these have been copied, there is found no trace of a closed, ascendant intestinal canal behind. Moreover, Jurine expressly says that he has seen the intestinal tube of *Distomum terectilis*, as coeca.


8 *Bucephalus polymorphus* is probably a harval
this canal is simple, straight, and ends posteriorly in an anus.\(^7\) In many Trematodes, the intestinal tubes have in all their course simple or ramified caeca, and in some, these caeca are so fully developed that the intestinal canal appears to fill the whole body.\(^8\) The intestinal walls here are very thin, but this does not prevent peristaltic and anti-peristaltic movements, by which their contents move backwards and forwards, and are often rejected through the mouth.\(^9\)

\[\text{§ 108.}\]

In the Nematodes, and Gordiacei, the intestinal canal passes straight from the mouth which is at the anterior extremity, through the cavity of the body to the anus, which, in the first, opens front of the caudal extremity.\(^10\) In very many Nematodes, the mouth has nodositics and swellings, but it is seldom that its cavity has horny, tooth-like processes.\(^11\)

From the mouth extends a long and very muscular oesophagus, which is usually dilated chælviform at its lower extremity. When the oesophagus is very long, it has one or more constrictions.\(^12\) It is nearly always composed of three longitudinal muscles which are united by longitudinal seams. The triangular cavity circumscribed by these muscles is lined by a very firm epithelium, which is sometimes horny, and in some species so thickly set in the clavate dilatation that it resembles a masticatory apparatus.\(^13\)

The intestine consists of a straight tube, with thin walls and without dilata

\[\text{Gasterostomum;}\] and the species above mentioned I have discovered in the intestinal canal of \[\text{Perca fluviatilis;}\] and \[\text{Lanio senecio.}\]

\[\text{§ 108.}\]

\[\text{In the Nematodes, and Gordiacei, the intestinal canal passes straight from the mouth which is at the anterior extremity, through the cavity of the body to the anus, which, in the first, opens front of the caudal extremity.}\]

\[\text{In very many Nematodes, the mouth has nodositics and swellings, but it is seldom that its cavity has horny, tooth-like processes.}\]

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\[\text{The intestine consists of a straight tube, with thin walls and without dilata}\]
tions, and which terminates in a short muscular rectum. The proper intestine is of a brown, greenish, or dirty yellow color, which is due to its walls being formed of compact cells filled with colored granules. The loose and cellular walls, having very feeble peristaltic movements, are surrounded externally by a kind of dense peritoneum, and lined internally by a very fine epithelium. In some species of Ascaris, the intestine is lengthened into a caecum at its junction with the oesophagus.

§ 109.

There are observed, here and there, only traces of appendant organs of the digestive canal.

In many Trematodes, there are upon each side of the neck, two more or less developed cords or canals, of a cellular aspect, and of a pale yellow color by direct light. They pass towards the mouth, open perhaps into its cavity, and have a function, probably, like that of salivary organs. In many Nematodes, two or four caeca extend from the cephalic extremity along the oesophagus, and as they open distinctly into the oral cavity, it is, therefore, the more probable that they should be regarded as salivary organs. The same signification should be given to the cephalic appendage found in many species of Ascaris, which extends from the constriction of the oesophagus to the beginning of the intestine.

Hepatic organs have been found nowhere but in the Nematodes; but it may be that the granular cells in the thick walls of the intestinal canal, take their place.

5 This epithelium has sometimes special infequilateral vesicles, which, with Ascaris asciutata, and spiculigera, form a regular zig-zag series, resembling the values of the intestinal mucous membrane of some vertebrates. With Ascaris aucta, they have the form of long, sharp villi.

6 This cephal appendage, accompanied usually with a constriction of the posterior end of the oesophagus, was first observed by Methis (lsis. 1851, p. 91, Taf. II. fig. 16, 17, 18). It is found with many Ascaris, but its length is very variable. In Ascaris heterura, semitera, and ensiculata, it is very short, and protrudes scarcely beyond the oesophageal constriction; while in Ascaris depres-cus, aucta, angulata, and macronata, it reaches to the middle of the oesophagus, and in Ascaris spi-culigera, osculata, and the species described as Filaria pinuncum, it extends nearly to the cephalic extremity.

7 These glandular-like organs are often very distinct in the exuviation of the Trematodes, and in many adults of Monostomum, and Disto-mum; see Wiesmann's Arch. 1841, II. p. 322.

2 Methis (lsis. 1851, p. 81, Taf. II. fig. 6) has observed with Strongylius armatus, an annular vessel surrounding the mouth, which communi-cates with it directly, and also with two cords accompanying the oesophagus. According to him, there is also a similar disposition with Strongylus hypostomus, and tetracanthus.

Similar appendages, analogous to salivary organs, occur, according to Owen, in the new genus Gnathostoma, as four caeca surrounding the oesophagus, and opening into the mouth (Wiesmann's Arch. 1853, I. p. 134). With Choeracanthus, and Anacanthus, there are four similar organs, and Diesing is certainly in error in regarding them as analogous to the ambulacral vessels of the Echinodermata (Ann. d. Winder Mus. II. Arch. 2, p. 224, 235, 258; Taf. XVIII. fig. 8, 9; Taf. XXII. fig. 5). I am disposed to regard as salivary organs, also, the two long caeca which pass from the mouth along the oesophagus of Strongylus striatus.

3 I have discovered a similar cephal appendage in a group of Ascaris known as Filaria pi niunctum (Wiesmann's Arch. 1859, I. p. 350); such are, Ascaris macronata, angulata, oscu-lata, spiculigera, aucta, acus, and labidula. It is remarkable that with the exception of the last two, all these have also a caecum upon the intestine.

§ 109, note 6.] See, for the alimentary canal of Ascaris infecta, Leidy (A. Flora and Fauna within living animals, Smithsonian Contrib. V. Art. 2, p. 43, Pl. VI. fig. 1-7). He divides it into a strongly muscular gizzard, a cylindrical intestine lined with hexahedral epithelium, and a pyriform rectum.

See also his description of that of Streptosomum, The lastomum, &c. (ibid. p. 49). In The-
CHAPTER VI.

CIRCULATORY SYSTEM.

§ 110.

Most of these animals have a vascular system. The circulating liquid is usually wholly colorless, and often contains vesicular or granular corpuscles, which are difficult to perceive from their delicacy and transparency. The circulation is due to the general contractions of the body or of the walls of the vessels.

In the Acanthocephali, the vessels have no proper walls, but are spread out, as has already been said (§ 106), in the subcutaneous parenchyma. There are two larger, lateral canals, which pass from the neck to the caudal extremity, sending off laterally numerous small canals, which anastomose with each other. A similar net-work is found in the proboscis through its whole length. These two canals connect also with the lemnisci, upon each side of the neck. These last, of which there are always two upon the sides of the proboscis, passing from the neck to the cavity of the body, are usually riband-like, and composed of a finely-granulated parenchyma, which, like the cutaneous one, has a system of vascular canals.

In most species of Echinorhynchus, this system consists of a main canal upon the border of the lemniscus, from which are sent off inwardly, numerous small branches. These last form the net-work which fills the parenchyma of the proboscis.

In many, the lemnisci are surrounded by muscular fibres, which, converging to the posterior extremity of these organs, form two short muscles, which, in their turn, are blended with those passing obliquely to the proboscideal sheath. The point of junction is at a short distance from the place where they are detached from the subcutaneous muscular layer. Each lemniscus is constricted into a narrow neck at its base, which passes into the skin at the base of the proboscis. The junction of the cutaneous with the lemniscian vascular system occurs at this point, as is indicated by the contained liquid passing backwards and forwards between the two from

1 This vascular system, taken by many Helminthologists for a digestive canal, has been figured by Westrumb (De Helminth Acanthocephalis Tab. II. fig. 10, 111. fig. 10, 12, 21), and Huron (Echinorhynchus strumus) Anat. 1836, fig. 1, 5). The movements of the nutritive liquid may be distinctly seen by placing these animals alive and undisturbed under the microscope. One will then be quickly convinced that the circulation is due to the general movements of the body. If Echinorhynchus is placed in much water, the absorption distends not only the body, but the canals of the vascular system are so filled that the subcutaneous parenchyma is swollen, and the skin is raised here and there into vesicles.

2 With Echinorhynchus angustatus, acus, fusiformis, proteus, and polymorphus, the two lemnisci have a riband-like form. In Echinorhynchus gibbus, they are very long; and in Echinorhynchus claviceps, they are longer than the body, and lie coiled in its cavity. In Echinorhynchus gibbus, hystrix, and strangulus, they are discoid and very short.

3 Echinorhynchus angustatus, haenca, polymorphus, proteus, and gibbus. As a whole exception, the principal canal occupies the median line of the lemniscus, and sends off laterally small branches, with Echinorhynchus gibbus. Here and there its course is broken by oval, voluminous, transparent and apparently vesicular bodies; see Westrumb loc. cit. Tab. II. fig. 7. Similar bodies in the lemnisc and subcutaneous parenchyma, are found with Echinorhynchus claviceps; see Muter, Zool. Danica. Tab. LXI. fig. 3. These bodies are, moreover, regular neither as to their number nor position, and I have not learned their nature.

4 Echinorhynchus acus, angustatus, fusiformis, and proteus.
the peristaltic actions of the body and the alternate retraction and pro-
traction of the proboscis. (6)

In the Gordiacci, and Nematodes, no vascular system has as yet been
found. Only in a group of species described as *Filaria piscinum*, has there
been found a riband-like organ concealed in the cavity of the body, and
traversed by a net-work of canals, which resemble those of the lemmisci of
the Acanthocephali. (6)

§ 111.

In the Cystici, Cestodes, and Trematodes, the vascular system is well
developed. Its canals have proper walls, the contraction of which pro-
duces the circulation. In the first two orders, it consists of two pairs of
longitudinal canals, which pass along the sides of the body and head, and
intercommunicate occasionally, by transverse canals. These four vessels
open, in the head, into an annular ring which surrounds the proboscideal
sheath; there is here, therefore, a completely isolated system. (3) In the
Trematodes, this system consists of a contractile net-work spread over
the whole body; and in which are two larger trunks, which pass along
the sides of the neck and body. (2)

5 Michis (Isis, 1831, p. 82) affirms to have seen
on the neck of *Echinorhynchus gigas* two small
orifices by which the loomed open outlets, but
I have been unable to see them in this species, or
others of this same genus. If they really exist,
they will shed light upon the doubtful functions of
these organs. From what we know of their struc-
ture, it is not improbable that they belong to the
nutritive system, and transude a liquid which
bathes and nourishes the organs in the cavity of
the body. 6

6 With the Nematodes, the liquid appears to
transude through the walls of the intestine into the
cavity of the body, and there bathes, without a vas-
cular system, all the organs. The riband-like organ
found in the *Filaria piscinum* (see Wiegmann's
Arch. 1838, 1, p. 310), and which I have also found
in *Ascaris ascocelata*, has the same vascular rami-
fications as the lemmisci of *Echinorhynchus gi-
gas*, and the vesicle-like bodies are not wanting
upon the course of the principal canal. Perhaps
they also transude the nutritive liquid, for I have
not found any communication between them and
the intestinal canals.

The two lateral enlargements also, which, as
already mentioned (§ 102), are extended between
the longitudinal muscles of the skin, have often
been regarded as sanguineous vessels; but I have
observed with them neither longitudinal nor lateral
canals.

1 These lateral vessels, regarded by some Hel-
mintiologues as intestinal tubes, give off in their
course no lateral branches, except these transverse
canals. With the articulated Cestodes, these last
are always situated at the posterior extremity of
the articulations, thus giving a bivalve-like aspect
of the entire vascular system. They are also
found, however, in *Caryophyllocus mutabilis*,
which is not articulated.

2 [§ 110, note 5.] The observations of *West-
rumb* and *Browne* on the circulatory system of
the Acanthocephali, have recently been thoroughly
verified by Blanchard, who has illustrated it with
excellent figures; see Ann. d. Sc. Nat. 1849, XII.
p. 21, and Régne animal, nouv. Édit. Zoophytes,
Pl. XXXIV. fig. 2 — Ed.

Plütner (Müller's Arch. 1838, p. 572, Taf.
XIII. fig. 4, 5) affirms to have seen semilunar valves
at the orifices of the transverse canals of *Taenia
solium*.

The four lateral cervical vessels which I have
observed not only in *Taenia*, but also in *Bothrio-
cephalus*, and *Cyathiformis*, may be traced with
perfect distinctness in *Taenia cyathiformis*, and
*serreta*, to the vascular ring which surrounds the
proboscideal sheath. With *Caryophyllocus muta-
bilis*, and *Taenia ocellata*, which are without a
proboscis, this vascular ring does not exist any
more than with *Bothrioccephalus*; here also the
four lateral vessels widely ramify in the head, and
form by anastomoses, a distinct net-work. *Both-
rioccephalus elatopus* has a similar organisation.
It should, moreover, be here observed that from
the contraction of its very thin walls the vascular
system easily evades the observer.

2 The vessels of the Trematodes are remarkable
for their prominent flexures; see *Distomum cir-
igerum*, *tereticollis*, *duplicum*, and the various
species of *Diplostomum* (Nordmann Microgr.
Beitr. H. 1. Taf. II. fig. 8, IV. fig. 5, 6). One
should not confound with the sanguineous vessels,
as has often been done, the very finely-ramified
canals of the excretory organ, which will hereafter
be mentioned. Thus I think that the vascular
net-work of *Distomum hepaticum* described by
Bojanus (Isis, 1829, p. 305, Taf. IV.) belongs to
this excretory organ. *Laurer* also (de Amphit-
tones cóndes, p. 10, fig. 22), has not carefully dis-
tinguished them; and *Nordmann* appears to have
fallen into the same error (loc. cit.).

With *Diplostomum*, the vessels open each side
into a large reservoir situated at the extremity of
the body. Between these two receptacles, the excretory
organ passes to the extremity of the body, and
*Nordmann* has taken its orifice as

1 [§ 110, note 6.] Berthold (Oeber den Bau
des Watersackes, &c. loc. cit.) has described a
vascular system with the Gordiacci; but *Blanchard*
(Ann. d. Sc. Nat. 1849, XII. p. 7) has failed to
confirm his statements after very careful research.

— Ed.
§ 112.

THE HELMINTHES.

CHAPTER VII.

RESPIRATORY SYSTEM.

§ 112.

A respiratory system has not yet been found with certainty in the Helminthes.

The pedunculated vesicles of many Nematodes, situated under the skin, and projecting into the cavity of the body, and which have great absorptive power, have been compared to tracheal pouches and branchiae; but their structure is so little known, that any opinion as to their function ought to be deferred.\(^1\)

A remarkable fact is the presence in some Trematodes of extremely active vibratile lobules, situated intermittingly on the inner surface of the walls of the vessels.\(^2\) It may be questioned if these vessels have a special function, different from that of the others. They somewhat resemble the aquiferous system of the Polyps, Acalephs, and Echinoderms, and like it, belong, perhaps, to the respiratory system. They differ, however, in not having openings which communicate outwardly; but, probably, they receive by endosmosis, water absorbed by the skin.\(^3\) But another objection to this view, is, that in this order there has been found nothing like blood-vessels.

belonging to the nutritive vessels. The nutritive liquid of the vascular system differs from the coarsely-granulated excretion of the excretory organ, by its homogeneous and colorless aspect.

It is remarkable that in *Dictostomum tereticollis* this liquid has a reddish color, which, in the finest capillaries has a yellowish cast; see Wiegmann's Arch. 1835, I. p. 53.

H. Mecke, likewise, thinks that the above-described vascular system of the Trematodes, is in direct communication with the secreting organ peculiar to these Helminthes; see Muller's Arch. 1836, p. 2, Taf. I. fig. 2.\(^4\)

1) *Bajunas* (ibis, 1831, p. 187, Taf. III. fig. 51–55) affirms to have observed in *Ascaris lumbricoides* these pedunculated vesicles, which are found also in *Ascaris depressa*, and *Strongylus gigas*, in connection with the lateral swellings; but this throws no light upon the nature of these vesicles, for we are yet ignorant of that of these swellings. The stigmata which he affirms (loc. cit. p. 187, Taf. III. fig. 56) to have observed upon these lines with *Ascaris acuta*, are, according to my own observations, only subcutaneous cell-like bodies.

2) I have quite distinctly seen these vesicles with *Diplostomum paradoxum*, *Aspidogaster conchicola*, *Dictostomum echinatum*, and an allied species of this last from the intestine of *Falco apivorus*.

I am yet uncertain if the vibratile organs found in the neck of *Distomum globiporum* and *nodulatum* (Wiegmann's Arch. 1835, I. p. 215), and in the parenchyma of *Dictostomum duplicatum* behind the ventral sucker, are of the same nature. Ehrenberg (Wiegmann's Arch. 1835, II. p. 125) was the first who observed this ciliary movement in the vessels of *Diplostomum*. When the motions of these lobules are free, there is a rapid current of the liquid, as Nordmann has remarked (Microg. Beitr. Hft. I. p. 65). But if an animal is compressed between two plates of glass, and their motions thus impeded, it will be quickly seen that these lust are the cause of the circulation; in fact, when the lobules cease moving, the colorless, homogeneous, and, without doubt circulatory liquid, is no longer perceived.

3) Barmeister (Handbuch d. Naturgesch. 1837, p. 525) compares, not without reason, this system to the tracheal system of insects, the first being *aqueous*, and the second *aerial* respiratory organs, thus confounding this vascular system of Helminthes with the excretory organ and duct found in most Trematodes. There may be, however, a comparison between these two systems, if we except the insects with stigmata, and take those which are aquatic and have a completely closed tracheal apparatus (see below), admitting no air from without.

\(\footnote{\text{\textsuperscript{1}} [§ 111, note 2.] Van Beneden (Ann. d. Sc. Nat. 1852, XVIII. p. 23) has recently expressed doubts upon the presence of a circulatory system with the Cestodes and Trematodes, but see the beautiful plates of Blanchard, Ann. d. Sc. Nat. 1848, X. Pl. XI. — Ed.} \)
CHAPTER VIII.

ORGANS OF SECRETION.

§ 113.

No organs of secretion have been found, except in the Trematodes and Nematodes. In most of the Trematodes, there is, upon the median line of the posterior part of the body, a contractile sac, which usually opens outwards, (1) at the caudal extremity, and seldom at the posterior part of the back. (2) This sac is single, (3) bifurcate, (4) or multiramose. In the last case, its branches are spread usually over the whole body. (5) Its walls are quite thin, and therefore, it is seen with difficulty when wholly contracted or empty. It contains a colorless liquid filled with numerous granules or vesicles, which, during the contractions, pass up and down, or escape through the external opening. (6) This organ is sometimes so crowded with clear, solid corpuscles, composed apparently of earthy matter, that examined by reflected light, it has a cetraceous aspect. (7)

In many Nematodes, there is on the ventral surface and at a variable distance from the head, a small oblique opening surrounded by a siphenter. In some species, two canals pass from it and run backwards on each side of the intestinal canal; and in others, there are also two other canals which extend forwards in the same way. The use of the colorless and homogeneous secretion of these organs is yet unknown. (8)

1 This opening, known as the Foramen caudale with Distomum, Holostomum, Monostomum, Aspidogaster, and Diplostomum, has formerly been compared to an anus by Nardo (Heussinger's Zeitch. für organisiche Phys. 1827, p. 68), and by Rucer (Ibid. II, p. 196). Mekhitis (Observ. de Distomate, p. 16) having shown that it belonged, in Distomum hepaticum, to a particular organ which is ramified like a vessel, has properly rejected this analogy; see Isia, 1831, p. 174. With the larvae of Trematodes, known as Cercaria, Liverphalus, and Distomum duplicaturn, the base of the tail is thrust into the excretory opening of this organ, and its contents cannot escape until the animal has lost the tail.

2 Amphistomum.

3 Monostomum faba, Distomum citrinum, Gasterostomum jimbriatum, and Liverphalus polymorphus.

4 Distomum chlorostomum, clavigerum, lima, maculosum, tereticollis, variecatum, and many species of Monostomum,—where the two closed ends of the sac often extend to the cephalic extremity. With Distomum appendiculatum, the two branches of the excretory organ unite directly behind the oral sucker. With Aspidogaster conchicola, it divides into two canals near the Foramen caudale, which extend to the anterior extremity. In Amphistomina, two similar canals wind from the head along each side of the body, to the middle of the posterior back, where they open outwards, after having formed by reunion a pyriform reservoir. Lourer (De Aspidistomato comis, p. 10, fig. 22) has given a figure of this reservoir, in which he has confounded the secretory canals with the nutritive vessels.

5 Beside Distomum hepaticum, Holostomum urinatum, the Distomum also with a spinous head, have a widely-ramified excretory organ; see Mekhitis, Isia, 1831, p. 182.

6 With the spinous-headed Distomum mitrate, and ceknaturn, this organ is often so reduced in substance, that here and there are perceived only isolated groups of the ramified canals.

7 The elasticity of these corpuscles may have been the reason why Ehrenberg (Symb. Physic. Anim. Evertebr. Ser. I. Physic. excreta) have taken those of Cercaria ephemerum for eggs, and the two canals of the excretory organ for ovaries; and why Nordmann (Microgr. Belit. H. 1, p. 54, Taf. 1, fig. 7) has regarded their escape from the body with Distomum annuligerum, as an act of oviposition.

8 The corpuscles of this kind found in the excretory organs of certain Trematodes, as for instance in a larva of Monostomum known as Cercaria ephemerum, remain one from their aspect, of the small calcareous subcutaneous bodies of many Fasciaria, and it may be asked if they are not an effete material, which, not being contained in proper organs, is with these Helminthes thus subcutaneously deposited.

9 This organ, to which I first called the attention in the dissertation de Borde (De evolutus Scaeniculis ac Ascaridio acuminata, 1841, p. 13), is composed of two canals which run backwards in Strongylus auricularis, Ascaris brevicaudata, and ascaridula salmonea (Boride, loc. cit. fig. 30, A. B.) and in Ascaris dactyluris, and paucipara, nuli (from the intestine of Testudo graecus), of two anterior and posterior canals, the common opening of which is near the middle of the body.
CHAPTER IX.

ORGANS OF GENERATION.

§ 114.

Although most of the Helminthes propagate by means of genital organs, yet there are a few species which multiply by fissuration and gemmation. The fissuration is always transverse, and differs from that of the Protozoa and Zoophytes in the fact that complete individuals are not produced, there being only a separation of certain organs from the perfect animal, as, for instance that of the segments of the body in the Cestodes. This fissuration is complete or incomplete. In the first case, occurring in the Taenia, the segments are detached from the body, and continue to live independently, without, however, ever forming a new individual.\(^1\)

Gemmation has been observed in the sexless Coenurus and Echinococcus. In Coenurus cerebralis, it is incomplete. The buds are formed on the internal surface of the parent-vesicle, and never separate from it, nor become perfect individuals. They have only a head and neck which project outwardly after the complete development. In Echinococcus, however, the gemmation is complete. The buds appear as in Coenurus, but the young animals are sooner or later detached and fall into the liquid of the parent vesicle. When completely developed, this vesicle bursts, and they are set at liberty. That their development occurs in this way is shown by their hanging by a cord, which, like the tail of Cercaria, is inserted into a fossa at the posterior extremity of the body. Like this last, also, this cord subsequently disappears, and the young animal moves freely about, by the aid of its double circle of hooks and its four suckers.\(^2\)

§ 115.

In those species which reproduce by male and female genital organs, these last are sometimes upon a single animal, and sometimes upon two separate individuals. The eggs and spermatic particles are formed after very different types. In all, the copulatory organs are extraordinarily developed.

The Cestodes and Trematodes are hermaphrodites.\(^3\) The structure of

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1 The imperfect fissuration with Ligula and Tricenuhphorus is limited almost to a constriction of the lateral borders. With Bothriocephalus punctatus, it is only here and there that a ring is detached, and over most of the body the transverse and opposite sulcations do not extend near to the median line. With Bothriocephalus tetrapterus, the fissuration is more complete; but even here, there are only some incompletely limited rings among numerous others which are completely so.

Of all Helminthes the Taenia have the most complete fissuration; here not only is the separation of the rings indicated by a complete furrow, but the rings are sometimes detached and live thus independently. The separated rings of Taenia solium, cucumieria, and others, move freely, and are so individualized, that they resemble some Trematodes.

2 See Chenmitz, De Hydatibus Echinococci hominis commentationis, 1834; Muller, in his Arch. 1836, p. CVII.; and Siebold, in Burdach's Physiol. II. 1837, p. 183.

3 According to Nordmann (Mecogr. Beitr. III. 2, p. 141), Diesing (Ann. d. Wiener Mus. I. Abh. 1, p. 9), and Miram (Nov. Act. Acad. XVII. pt. 2, p. 650), the male and female genital organs of the genus Pentastomum, classed by many modern Helminthologists among the Trematodes, are situated upon different individuals. But Owen affirms to have observed the opposite (Trans. of the Zool. Soc. of London, 1835, I. p. 555). The only way to settle this point is by analyzing accurately the contents of these organs; a method pursued by Valentin (Repertorium III. 1837, p. 135), who found filamentoid spermatic particles in the organs of an apparently female
the genital organs of the first is yet imperfectly known; while that of those of the second is well understood. The female apparatus of the Trematodes consists of a germ-forming organ (ovary), with its excretory duct; then, two others for forming the vitellus, which have also excretory ducts; and then a simple uterus with its vagina. The male apparatus consists of testicles with their excretory canals, an internal seminal vesicle, a cirrhus-sac, an external seminal vesicle, and a penis.

The ovary consists of a round or pyriform reservoir, situated, usually, upon the median line of the body, from which it is distinguished by its pale color and transparency. It is filled with simple round cells—the egg-germs. The nucleus of these cells is the germinative vesicle, and the nucleolus, the germinative dot.

The short and small excretory duct of the ovary opens at the commencement of the uterus. The organs which secrete the vitellus are two in number, of variable length, and situated upon each side of the body near the dorsal surface; they occupy either the cervical, the central, or the posterior portion of the animal, and sometimes extend over them all. They are nearly always composed of ramified caeca filled with white, granular, vitelline corpuscles. By reflected light these caeca appear through the skin as a white, ramified, botryoidal mass, and from each of them, pass off inwardly, numerous excretory ducts, which reunitci opposite the ovary into two common canals. These last approach each other transversely, and form a single canal upon the median line, which, after a short course, opens at the bottom of the uterus by an orifice which is common to it and the ovary.

**Pentastomum taenioides**, organs which are regarded by Diesing as caeca for secreting the envelope of the eggs.

Since all the parts of the genital organs of *Pentastomum* have not been examined with this same precision, I can give no opinion as to their use.  

2 See Siebold, in Wiegmann's Arch. 1836, I, p. 217, Taf. VI., and in Maller's Arch. 1836, p. 252, Taf. X. fig. 1.

3 The ovary here is always smaller than the testicle, and sometimes as to form very closely resembles it, as in *Distomum globiporum*, and *longicollum*, mild (from the urinary bladder of *Calus gabia*); consequently it may easily be taken for a third testicle.

4 With Monostomum, it lies wholly at the posterior extremity.

5 In Polystomum, Octothorium and Diplozoons, the germs are so large that they may easily be taken for perfect eggs.

There is here, moreover, between the cell-wall and the nucleus (the germinative vesicle), quite a thick layer of albuminous substance, somewhat representing a vitellus. But in the other Trematodes it is so thin as scarcely to be perceived.

6 With the following Trematodes there is a wide deviation from this usual arrangement. In *Distomum longicollum* the organs producing the vitellus are two simple round caeca located behind the ventral sucker; in *Distomum cynognathus*, they are two very small deeply- fissured bodies; and in *Distomum gibbaum*, there is one only, which is star-shaped and located at the middle of the body.

7 These organs, until now regarded as ovaries, secrete only vitelline cells. With most Trematodes their nuclei are clear, and have been taken for eggs. In eggs recently formed, one can always distinguish these cells from the germs. In passing the excretory canals they are compressed and elongated, but never run into each other. When these canals are crowded, they have the aspect of white cords, which have often been taken for nerves. But when they are empty, they, as well as the vitellus-secreting organs, are almost invisible.

* [§ 115, note 1.] See upon this subject Van Beneden (Ann. d. Sc. Nat. XI. 1849, p. 326), who has described in detail the sexual organs of *Linguatula diesingii*, and has shown the sexes to be separate. See also my note under § 99. — Ed.

† [§ 115, note 7.] To say that certain organs secrete vitelline cells, is a little obscure, and no doubt Siebold intended to convey the meaning that they secreted the plastic material out of which these cells are formed. I make this perhaps seemingly unnecessary reference to the matter, since it concerns the subject of the development of the ovum. In the *Ascaris*, where the origin and development of the ovum can be satisfactorily studied, you first notice the germs as nucleated cells, of which the nucleus is the future germinative vesicle and the nucleolus the germinative dot. These cells increase in size, and as they move along there appear in the liquid which lies between the nucleus and the cell-wall minute granules which ultimately become cells; in this way the vitellus is formed, the formation being endogenous and not exogenous. These special organs or tubes therefore are vitellus-forming organs, in virtue of their secreting the forming material out of which the vitellus is formed within the original nucleated germ-cell. — Ed.
§ 115. THE HEMINTHES.

The neck of the internal seminal vesicle (Vesicula seminalis interior), discharges its contents at this same place into the uterus, through a special Vas deferens from one of the testicles. The Uterus commences as a narrow tube, which may be regarded as a Tuba Fallopian. Its dilated portion, which has powerful peristaltic motions notwithstanding its thin walls, is throughout of nearly an equal diameter. It winds through a large portion of the body and terminates in a narrow, more or less straight, muscular vagina, which always opens externally by the side of the penis.\(^8\)

The testicles, of which there are usually two,\(^9\) are generally of a round or oval form,\(^{10}\) and located in the posterior region of the body, nearly always one before the other.\(^{11}\) They are transparent and colorless, and the filiform spermatic particles are extremely small and active.\(^{12}\) The two Vas deferentia open into the cirrhus-sac, which is perforated at its bottom to communicate with the Vesicula seminalis exterior.\(^{13}\) From each testicle there passes off, also, a third Vas deferens which opens into the neck of the Vesicula seminalis interior.\(^{14}\) The cirrhus-sac is pyriformly elongate, or round,\(^{15}\) and the Vesicula seminalis exterior is always situated at its base. This last is prolonged, opposite the openings of the vasa deferentia, into usually a very long, tortuous Ductus ejaculatorius, which opens into a tubular penis.\(^{16}\) There is one common genital opening for the penis and vagina which are usually side by side, and out of which the penis often considerably projects.\(^{17}\) In most Trematodes, these two organs are located at the anterior extremity of the body, and only in Holostomum, and Gasterostomum, are they removed to the other extremity.\(^{18}\)

\(^8\) The length of the uterus varies very much in different genera and species, and its coils are always irregular. With Monostomum mutabile, and verrucosum, the ovicidal arising in the posterior extremity, passes in front with numerous transverse coils.

\(^9\) I have found one testicle only, in Amphistomum sublenticulatum, and Aspidogaster canchiota, although I have seen three or four in Distomum appendiculatum, and oxytuTum,

\(^{10}\) With Distomum ovatum, the two testicles are side by side behind the ventral sucker; with Distomum eh stosomum, they are on each side of this sucker, and with Distomum crassum, mid (from the intestine of Hirundo domestica), they are in front of it, on each side of the neck.

\(^{11}\) With Distomum brevicauda, Inernostomum, oxyrum, echinatum, globiporum, and Amphistomum conicum, the testicles have many depressions; see Bojanus, loc. 1821, Taf. 11, fig. 13–17; Bürmeister and Schlotheim, in Wiegmann's Arch. 1833, Taf. 11, Taf. 41; also Lauer, De Amphistomoso conico. fig. 21, 24, 25. With Amphistomum sublenticulatum, giganteum, and Distomum bisporum, the number and depth of these depressions gives the testicle the aspect of a bundle of caras; see Bojanus, loc. cit. Taf. 11, fig. 14–17, and Diesing Ann. d. Wiener Mus. 1. Abth. 2, Taf. XXII.

\(^{12}\) In the testicles of the Trematodes, the development of the spermatic particles occurs after the usual mode. The bundles which they form are separated in their passing the vasa deferentia, and they collect into irregular masses in the seminal vesicles. Their extremely active movements cannot be perceived unless they are quite isolated. When put in water they become twirled together, and assume a loop-like arrangement,—their motions instantly ceasing.

For the development of the spermatic particles of the Trematodes, see Kolliker, Die Bildung des Samenfaden in den Wirbelthieren, loc. cit. p. 44, fig. 8.

\(^{13}\) These two vasa deferentia are sometimes blended together before reaching their destination; this is so in Distomum variegatum, and lanceolatum.

\(^{14}\) The internal seminal vesicle is so extraordinarily large in Distomum variegatum that it exceeds that of the ovary and two testicles.

\(^{15}\) This cirrhus-sac, together with the penis, is very long with Distomum luna, maculosum, variegatum, and ovatum; but it is especially so with Aspidogaster canchiota, and Monostomum verrucosum.

\(^{16}\) The protruding cirrhus or penis of Distomum holostomum is provided with small bunches; and that of Monostomum verrucosum with numberless little warts.

\(^{17}\) When the penis is protruded, it may then be seen how the contents of the vagina are emptied at its base. When the common genital opening is closed, the very flexible penis can be turned into the vagina and there discharge its contents, and in this way the self-impregnation of these animals may occur.

\(^{18}\) The common genital opening is usually situated on the middle of the neck, and with Distomum, it is directly in front of the ventral sucker. With Distomum eh stosomum, and ovatum, it is upon the sides of the neck, and with Distomum caudale, and holostomum, exceptionally, it is on

ured the spermatic particles of Polystomum appendiculatum as Cercaria-form. — Ed.
the posterior extremity of the body. Its position is indicated, even when the penis is not protruded, by a small papilla.

With *Octobothrium*, and *Polystomum*, there is a round muscular sac conelated directly behind this opening, which contains a circle of delicate bony ribs, the lower extremities of which are bifid and form a support like a hovest. Moyer (Bilder loc. cit. p. 21, Taf. III. fig. 3, 6) has seen bony ribs with *Octobothrium lanceolatum*. I have found eight with *Polystomum interzerratum*, and forty with *Polystomum ocellatum*. Their use is wholly unknown to me.

The eggs of the Trematodes have apparently only a single envelope. Among the normal eggs in the uterus may often be found others which are malformed, also very irregular bodies of a yellowish or brown color, formed almost entirely of the substance of these envelopes. These bodies were most probably secreted by the walls of the uterus (the *Tuba Fertilis*) at a time when the ovaries and the secreting organs of the vitellus were inactive, so that the substance of the envelopes was hardened before receiving their usual contents. With *Amphistomum subebelatum*, *Octobothrium lanceolatum*, *Polystomum interzerratum*, and *oeclatum*, and *Diplostomum paradocium*, the eggs are very large, and in the last-named species their extremities are narrowed and lengthened into a spiral filament; whereas one of these eggs has been taken for a testicle and penis; see *Nordmann Microg. Bilder. Hth. 1, p. 75, Taf. V. VI. fig. 1, 2; also *Hartig*, in *Muller's Arch. 1841*, p. 34, Taf. II. fig. 11. The eggs of *Monostomum verrucosum*, and some other species of this genus which live in the intestine of *Chelone eculenta*, have a very different form; they are oval and colorless, and at each extremity have two papillae, which are gradually developed into very long, sharp appendages; see *Dujardin*, Hist. Nat. d. Helm. d. P. VIII. fig. 6, B. 3.7

With *Caryophyllaeus mutabilis*, there is only a single circular-sac upon the ventral surface of the posterior body, and from which a delicate long penis often protrudes.

I think I have seen an ovary in each of the segments of *Bothriocephalus punctatus*, and *Taenia ocellata*. As such, ought, perhaps, to be regarded those organs which *Eschricht* (Nov. Act. Acad. Loop. XIX. Suppl. 2, Tab. I. fig. 2, 6, 8) has considered with *Bothriocephalus latus* to be ovaries. The organs secreting the vitellus are a mass of irregularly arranged granulatus situated upon both the dorsal and the ventral surfaces, and which have very fine excretory ducts. This mass, called by *Eschricht* loc. cit. p. 25, Tab. I. fig. 6, the ventral and dorsal granules, can be, together with its excretory ducts, be made out, except when filled with the vitelline substance. With *Taeinia ocellata*, the vitelline organs are limited to the sides of each segment, at the anterior border of which two main excretory ducts are easily seen; these form a single short canal in the middle of the body. In this same place are two transversely-placed oval sacs, and which are probably the two ovaries.

The uterine convolutions are generally in the middle of the body, and when filled with mature eggs, appear through the skin as a brown rosette; see *Eschricht* loc. cit. Tab. I. II. (*Bothriocephalus latus*).

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* [§ 115, note 19.] See also for the structure of the genital organs *Taeuer, Muller's Arch. 1850*, p. 602, Taf. XX. fig. 17 (*Polystomum appendiculatum*). — *Ed.
Taenia, it is a reservoir, composed of numerous ramified coeca, and intimately blended with the parenchyma of the body. (22) The vagina is a narrow, muscular canal, which usually opens close to the penis by a special orifice (Vulva), or by a common genital opening (Porus genitalis).

It is difficult to decide whether the testicles, which always form the middle layer of the body, consist of a collection of inter-opening coeca, or of a single spirally-rolled tube. The cirrhus-sac with the Vas deferens opening at its bottom, is always very distinct. As in the Trematodes, it has a Vesicula seminalis, with a Ductus ejaculatorius and a muscular penis. (23)

The contents of the different canals, the seminal vesicle and the ejaculatory duct, are always very active, filiform spermatic particles. (25) The genital openings are upon the middle of the ventral surface, or on the lateral borders of the body; but in those species where the sexual openings are separate, they are lateral for the male, and ventral for the female. (56)

The eggs of the Cestodes, situated like those of the Trematodes in a spiral, pouch-like uterus, have also a similar structure. Their simple, oval, brownish-yellow envelope, has also, sometimes, an operculum. The eggs of Taenia have a very different structure; the envelope is colorless, and of a very variable, and sometimes quite remarkable form. (27)

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22 With most Taenias the borders of the cellular uterus are very difficult to distinguish. But its lateral coeca with Taenia ocellata, and its arborescent divisions with Taenia solium, are very easily seen; see Delia Chinea, Compandio di Echinointegra umana, Tav. III. fig. 10.

23 The cirrhus-sac is either short and pyriform, or very long. With very many Taenias, as with Taenia amphitricha, lanceolata, multisetiata, sceletina, and setigera, the penis has numerous small spines pointing backwards; see Dujardin, Hist. d. Helm. Pl. IX.—X. That of Taenia infundibuliformis is surounded with very large bristles; and according to Dujardin (loc. cit. Pl. IX. B. 210) this is also true with Taenia sinuosa.

24 By very slight pressure, the spermatic particles contained in the Vesicula seminalis of the cirrhus-sac are pressed out through the penis; this is so with Bothriochephus punctatus, latus, Taenia cucumerina, planiceps (from the intestine of Cavia porcellus), infundibuliformis, serrentalus, and villosus. As with the Trematodes, the spermatic particles here cease to move when put in water, and are twisted into disks. (26)

25 With Ligula, Bothriochephus nodosus, latus, claviceps, dilatatum, punctatum, and te- trotripes, the two genital openings are situated on each side of the ventral surface, while the penis protrudes from a special opening directly in front of the vulva; see Mchis in Isa, 1833, Tab. 1. fig. 1, 2, and Essericht, loc. cit. Tab. I. fig. 5.

With Bothriochephus punctatus, there are two pairs of these openings upon each segment, one under the other, but in Bothriochephus te- trotripes, these are side by side. With Triacora- porus, nodosus, and Taenia ocellata, the valva is upon the ventral surface, and the penis upon the lateral border. With Bothriochephus fri-
THE HELMINTHES. § 116.

§ 116.

In the Acanthocephali, the genital organs occupy a large portion of the cavity of the body. They arise in the posterior portion, and are supported by a Ligamentum suspensorium, which extends from this last to the base of the proboscideal sheath.

In the females, there are neither proper ovaries, nor an uterus; but in their place there are numerous oval, or round, flattened bodies of considerable size, which float freely in the liquid of the cavity of the body; they have nicely-defined borders, and are composed of a vesicular, granular substance, and, as eggs are formed within them, they may be regarded as so many loose ovaries.\(^\text{2}\)

When the eggs have reached a certain size, they fall from the ovaries into the cavity of the body. At this time they are ovo-elongate, have only a single envelope, and contain both a vesicular and a finely-granular substance, but no trace of a germinative vesicle. They continue to increase in size, and two new envelopes are formed about them.\(^\text{3}\) The muscular canal which passes off from the simple vulva which is situated at the posterior part of the body, may be regarded as a uterus.

At the point where it is attached to the Ligamentum suspensorium, it becomes a campanulate or infundibuliform organ, whose borders float freely in the cavity of the body, and thus the whole is comparable to a Tuba Fallopii. The bottom of this bell-shaped organ communicates with the superior extremity of the uterus by a narrow, valvular opening, which presents a lateral, semilunar fissure.

This whole organ is endowed with very active peristaltic motions, by which the loose contents of the cavity of the body are absorbed; and while the larger ovaries are thrown out, the little immature eggs are returned into the cavity of the body by the lateral fissure, — the more mature ones only, reaching the uterus.\(^\text{3}\) This uterus, which is of variable length, opens outwardly through a very short and narrow vagina.

The males of Echinorhynchus have usually two oval or elongated testicles, one before the other, and attached to the Ligamentum suspensorium.

of Taenia cucumerina (Creplin, Oeuvres de Entozaä fig. 12, 18) and cuteriformia, have the remarkable arrangement of being grouped in tens to twenties, and each group is surrounded by a glistening envelope.\(^\text{2}\)

\(^\text{1}\) The ovaries of Echinorhynchus were formerly taken both for mature eggs, and for coxylodons; and to this is due the very inaccurate figures of them by Westrum and Cloquet (loc. cit.). Dujardin, however (Hist. d. Helm. Pl. VII. fig. D. 6), perceived their true nature.

A state of development which I have observed with many females of Echinorhynchus globosus, would appear to throw some light upon the question as to the part of the body where the ovaries are first formed. Here the Ligamentum suspensorium had, over most of its extent, large granular globules, while the cavity of the body contained neither ovaries nor eggs. I think, therefore, that this ligament is the elementary material from which the ovaries are developed under the form of globules, which, being subsequently detached, continue their development in the liquid of the cavity of the body.

\(^\text{2}\) The long eggs of many Echinorhynchus are formed by the same process. They are all colorless, and may be distinguished by the peculiar aspect of their middle envelope which at both extremities is constricted like a neck. But those of Echino-

\(^\text{3}\) rhynchus gigas form an exception; for they are shorter and oval, their middle envelope is yellowish, and, like the two others, has externally numberless small obscure spines. With Echinorhynchus stru-

\(^\text{4}\) musos, hystrix, anguistatus, and proteus, the external envelope of the eggs presents the peculiar phenomenon that when pressed between two plates of glass, it separates into very fine fibres.

\(^\text{5}\) The nature of this campanulate Tuba Fallopii has been wholly mistaken by Bujanus, Westrum and Cloquet. Burrow (Echinorhynchus strumosus) Anat. p. 22, fig. 1, g, fig. 6) was the first to describe it, without however conveying the correct idea. See my description (Burrow’s Physiol. loc. cit. p. 197), which has been confirmed since by Dujardin (Hist. d. Helm. p. 495, Pl. VII. fig. D. 5).

\(^\text{6}\) See [§ 115, note 27.] See Van Beneden (loc. cit. p. 67), who has observed the eggs of the Cestodes composed like those other animals,—with a germinative vesicle, &c. — Eu.
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They send off two varicose Vasa deferentia to the posterior portion of the body, where, after uniting very probably with the neck of an odd elongated vesicle (Vesicula seminalis?), they are prolonged into a copulatory organ. There are six pyriform bodies, which secrete a finely-granular substance, and are attached behind the testicles to the Vasa deferentia. Their six excretory ducts successively unite, ending finally in two which open into the copulatory organ. The penis is usually folded inward, but when projecting outwardly, it is a muscular, cup-shaped appendage, whose fossa receives the posterior portion of the body of the female during copulation.

The spermatic particles are developed after the usual mode; they are filliform and very active, and quickly die in water, interlooping and twisting together.

The very adhesive, viscidous, yellowish-brown wax-like substance, often found about the vulva, is apparently the secretion of the pyriform bodies during copulation.

§ 117.

With the Nematodes, the genital organs consist of a long, simple or partly double caecal tube, which winds around the straight intestine.

In the female it has the following parts: Ovarium, Tuba Fallopii, Uterus, and Vagina; and in the male, Testes, Vas deferens, Vesicula seminalis, and Ductus ejaculatorius.

With Trichosoma, Trichocephalus, and Sphaerularia, the genital tube is simple in the females, and usually so in the males. But in Filaria, Ascaris, Strongylus, Spiroptera, Oxyuris, and Anguillula, the ovary, Fallopian tube, and uterus, are double. In the females, the ovary is the posterior portion of this genital tube, and in its terminal portion are small round

4 With Echinorhynchus strumosus, these two round testicles are side by side. Having always found the cord, long vesicle empty, I cannot decide whether or not it serves the function of a seminal vesicle.

5 These six pyriform bodies were formerly taken for seminal vesicles; see Westrum, de Holmuth. Acanthocephali, p. 56, Tab. III. fig. 24; and Nitzsch, in Ersch and Grotsch's Encyclop. VII. 1831, plate for the Acanthocephali, fig. 2, 3, i. With Echinorhynchus claviceps, I have only seen one of these bodies.

6 The copulatory organ, which protrudes from a mossy white direction, has been very exactly figured by Du Jardin (Hist. d. Helm. p. 493, Pl. VII. fig. 1, 1, D, 2).

7 For the spermatic particles of the Acanthocephali, see my observations in Muller's Arch. 1836, p. 232.

8 This waxy substance incrusts sometimes the whole caudal extremity of females; this is so with Echinorhynchus gigas, and globocaudatus; see Cloquet (Anat. &c. à la p. 100, Pl. VIII. fig. 4, 5) and Nitzsch (Wiegmann's Arch. 1837, I. p. 64.)

1 For the simple genital tube with its various parts of the female of Trichocephalus dispar, see Mayer, Beitr. &c. Taf. II. With Filaria rigida, and Ascaris pacificana, I have found the female organs likewise simple. When these organs are double, either one uterus with its ovary and excretory duct passes in front from the simple vagina, while the other passes behind, as is the case with Ascaris brevicaudata, magrovenosa, Oxyuris vermicularis, Spiroptera anthus, Strongylus auricularis, and strisius; or both pass side by side behind, as in Ascaris acuta, mygus, tambriiroides (Cloquet, Anat. &c. Pl. L. fig. 2) and oxyuris. With Cuceolana elegans, and microcephalus (from the intestine of Ento tutoris), the uterus alone is double; one horn terminating posteriorly in a cecum without an ovary or Fallopian tube, while the other, which has these parts, passes in front. There are, moreover, species of Ascaris into whose vagina open three or four genital tubes. Thus with Ascaris microcephalus, I have seen the uteri divide upon reaching the vagina into three tubes, each having an ovary and excretory duct. According to Nathusius (Wiegmann's Arch. 1837, I. p. 57), the uterus of Filaria tubifera, which is at first simple, divides at its posterior extremity into five tubes.

The double uteri of Strongylus inflexus has, posteriorly, numerous constrictions, giving it a moniliform aspect.

* [§ 117, note 5.] For some further details on the genitaria of the Acanthocephali, see Blanchard (Ann. d. Sc. Nat. 1849, XII. p. 23), and Logne.
cells; in the anterior portion, these cells are more numerous and begin to be surrounded by a granular vitelline substance, in which the primitive nucleated cells are still seen; these cells therefore, ought perhaps to be regarded as germinative vesicles. In front, these eggs, which are of a discoidal form, are arranged in a row, or are grouped closely around a rachis which traverses the axis of the ovary. In the Fallopian tube, which may be known by its less diameter, the eggs become more mature, and, having been surrounded by a double colorless envelope, pass into the base of the uterus. This last is the largest portion of the genital tube, and is distinguished by its well-marked power of peristaltic action. The vagina, which is distinguished from the uterus by its narrowness and its muscular walls, opens at very different points of the body. Generally, as for instance in Ascaris, Spiroptera, Strongylos, Oxycaris, Cucullanus, and Trichocephalus, the Vulva, consisting of a transverse fissure, and often surrounded by a very remarkable fleshy swelling, is situated either a little in front of, or near the middle of the body; but sometimes it opens just in front of the anus. The sperm is usually so accumulated in the bottom of the uterus, that this is probably the locality of fecundation.

In the males, the posterior portion of this tube is the testicle; another portion of it, which is short and constricted, is the Vas deferens, which passes into a dilated portion,—the Vesicula seminalis. Usually this last is separated by a constriction from the Ductus ejaculatorius, which opens into another muscular tube (sheath of the penis). At the anterior portion of this last, is a horny, copulatory apparatus. The simple or double penis is of variable length, and is protruded by the muscular contractions of its sheath through the external opening, which is always situated at the poste-

2 The formation of eggs in various Nematodes has been described by Siebold (Rud. Arch. Phys. etc. p. 285), by Bugge (Diss. d. Stron-
gylos, &c. fig. 1–5), and Kolliker (Müller's Arch. 1843, p. 63, Taf. VI. fig. 2). I have found a rachis in the ovaries of Ascaris suis, lumbrici-
coidea, mystax, asculetata, Cucullanus elegans, and Strongylos infausta. The eggs of these, while yet immature and flattish, have a point on one of their extremities by which they are attached to the rachis.

With those of Ascaris lumbricoides, this point is very long during a certain period of development, and the opposite end has many deep sali-
tions, giving it a remarkable appearance; see Heurlin, in Müller's Arch. 1853, p. 502, Taf. XIV. fig. 11.

In the mature eggs, which are nearly always oval, it is rare that the double colorless envelope can be clearly perceived. With Trichostrongylus, and Tri-
chocephalus, there is a short diverticulum at each extremity of the egg. But in Ascaris dendata, there is at this same place a long filibrated filament; see Mayer, Bist. Taf. II. fig. 8, and Kolliker, in Müller's Arch. 1843, Taf. VI. fig. 16–19.

With Ascaris dendataris, Cucullanus eleg-
ans, Strongylos nodularis, and striatus, the borders of the vulva appear quite swollen. With Trichostrongylus, this swelling is so attached to the vulva as to resemble a propeucus of the vagina (Dujardin, Hist. d. Helm. Pl. I.).

With Filaria attenuata, infausta, caudata, mili (from the palaeonary eggs of Delphinius pho-
caen), and papillosa (see Lellon, Quelques matériaux pour servir à l'histoire des Filaries et des Strongyles, 1836, Pl. II. fig. 3), the vulva is at the side of the mouth. With Strongylos paradoxus, it is swollen to the form of a bladder, and is situated near the narial extremity; while that of Ascaris procyonaria is directly upon the anus.

4 See Bugge, loc. cit. p. 12; and Kolliker, in Müller's Arch. 1843, p. 72.

5 For the male genital tube, see Mayer, Bist. Taf. I., and Cloquet, Anat. &c. Pl. II. fig. 8. As yet I have observed only a few exceptions to this typical form with male Nema-
todes.

With Filaria attenuata, the posterior portion of the testicle is bifurcate, and with Ascaris ves-
icularis, there are two moderately large coecal pro-
longations which arise from the Vesicula semi-
nalis at the place where it empties into the Vas deferens.

[§ 117, note 2.] Primitively, the ova of Asca-
ris consist of nucleated cells, which are polyhe-
dral from mutual pressure. These increase in size gradually, in their passage down towards the ori-
duct, and the granules of the liquid lying between the nucleus or germinative vessel and the cell-wall become developed into cells, and in this way the mature ova are formed. Probably no better oppor-
tunity is afforded to perceive that morphologi-
cally the ovum is at first only a nucleated or nucleated cell; see Leidy, loc. cit. p. 45, Pl. VII. fig. 14, c. — Ed.
rerior portion of the body,\(^6\) It has a great variety of forms, and from its sheath arise two antagonistic muscles, which are inserted at its base.\(^7\) The spertic particles, which are always motionless, have usually a cell-form, or, at least, are never filiform corpuscles.\(^8\) For aiding the union of the sexes during copulation, the males have lobular appendages, papillae, and suckers, situated about the genital opening. Without doubt, the spiral posterior extremity also of the animal, is often used for the same purpose. Moreover, in many instances, there is secreted a wax-like substance intended to fasten the two sexes together.\(^9\)

\(^6\) According to Leblond (loc. cit. p. 29, Pl. III. fig. 1), both the male and female genital openings with *Flaria papillosa* are quite near the oral orifice. I have been unable to confirm this observation, at least with *Flaria attenuata, infecto-caudata* and a *Ascarius* situated in the thoracic cavity of *Starnus vulgaris*.

\(^7\) With *Trichosclithes* and *Trichosoma*, the posterior extremity is very long, and, beside the muscular sheath, has another which is membraneous, and sometimes covered with small spaces pointing backwards. This sheath, being folded forwards when the penis is protruded, is comparable to a *Prapututum*; see Mayer, Beitr. loc. cit. Tafl. I., and Dojardin, Hist. d. Helmin. Pl. I.-III. With nearly all the other *Nematodes* the penis is double. It is very long with *Ascaris acuminata, brevi-caudata, depressa, spinicirera, and Strongylus paradoxus*; but is very short with *Ascarius caudota, semiteres, Cucullanus elegans, Flaria attenuata, infecto-caudata, Spiroptera an-thiaris, and Strongylus infectus*. With *Spiropera*, the two penes are of unequal length, and with *Ascarius pascipara, brevi-caudata*, and *Strongylus*, there is an additional horny piece like a third penis.

With most *Nematodes*, the penes are separated, and those of *Strongylus* have a singular form due to the presence of numerous appendages. The two delicate, retractable muscles of this organ, arise from the internal surface of the cavity of the body, and when the pen is erected there are two pairs.

With *Ascarius osculata, vescularis*, and *spiculifera*, I have found these four muscles very long. See upon the penis of the *Nematodes*, Mayer, Beitr. Tafl. I., and Dojardin, Hist. d. Helmin. Pl. I.-VI.

\(^8\) For the spertic particles of the *Nematodes*, see Bugge, Dissert. de Strongylo, &c., p. 12, fig. 27, 28. The development of these cell-like spertic particles may be easily observed with *Ascaris pascipara*, where the parent-cells are very large. In the posterior end of the testicle the nuclei with their nucleoli are first formed; afterwards these nuclei are surrounded by a finely-granular substance around which the cell-membrane is formed.

In this state the testicle exactly resembles an ovary filled with sperm. Still later, the parent-cell membrane increases more and more, and the granular substance is found only upon the internal surface of the cell. During these changes, the nucleus which resembles a perinuclear vesicle, is transformed into a long, solid, and nearly-circumscribed corpuscle. *With Strongylus acicularis*, the spermatic cells (fig. 7) are pyriform; and with *Oxyuris ambiguus* their form is similar (Kölker, loc. cit. p. 73, Tafl. VII. fig. 25).

It is very probable that Mayer's assertion (Neue Untersuch. aus dem Gebiete der Anat. u. Physiol. 1842, p. 9) that he had seen thread-like spertic particles with *Oxyuris vermicularis*, has led Kölker to regard these pyriform cells as so many bundles of filamentoid spermatic particles. But never have I seen filaments of this kind in the *Nematodes*.

The pyriform spermatic particles of *Strongylus acicularis*, which have a short, pointed, as well as the round, cell-like, and nucleated ones of *Ascaris acuminata*, have been figured by Reichert (Beitr. zur Entwicklung der Räumenskörp. bei den *Nematoden*). This same naturalist has shown that these spermatic particles arise by endogenous generation, by fours in each cell; see Mayer's Arch. 1847, p. 88, Tafl. VI.*

\(^9\) The large caudal valve of the male *Strongylus*, and the spiral tul of the male *Spiroptera*, may be here instanced. With very many male *Ascaris*, there are two rows of papillae upon the sides of the genital opening, and with *Ascaris vescularis, and infecta*, I have found a copulatory sucker directly in front of this opening. The male of *Haemidra androphora* winds himself about the female during copulation, and the caudal valve of the male *Strongylus trachaeidis* glues itself so a daughter-cell (see my Memoir, The Origin, Development, and Nature of the Spermatic Particles in the four classes of Vertebrata, in the Mem. Amer. Acad. of Arts and Sc. 1855). The view of Reichert, therefore, that these spermatic particles are here formed in one cell, does not appear to me admissible, although I have no observations upon the instance in question. It appears to me explicable in this way: the nucleus of the parent sperm-cell underwent here only a second segmentation, thereby only four daughter-cells being produced. The nucleus of each of these became a spermatic particle, and these four particles passed into the cavity of the parent-cell. Reichert therefore, probably saw four spermatic particles in a parent and not in a daughter cell. — Eo.
The few observations hitherto made upon the genital organs of the Gordiacei have shown that they are wholly tubular as in the Nematodes. But their intimate structure, and the development of their sperrmatic particles are so strikingly different, that this point alone would justify their separation from the Nematodes.\(^{(10)}\)

§ 118.

With the exception of the Nematodes, and Gordiacei, the development of all Helminthes, which reproduce by means of genital organs and eggs, is metamorphic. A complete series, from beginning to end of these metamorphoses has yet never been observed with any species. From the separate parts of it here and there which have been observed, there appears the remarkable fact, that the embryos after escaping the egg, are not always changed at the end of the metamorphosis, into individuals like the parent, but appear as larva-like animals, capable in their turn of producing other larvae. These last larvae alone, change into individuals, which are like the parent.

This particular kind of transformation and development which is quite common among the Trematodes, has received the name of *Alternate Generation*.\(^{(10)}\) Whether it occurs among the Cestodes and Acanthocephali, cannot now be stated positively, for as yet we are unacquainted with the first period of their metamorphosis,—the embryo as it escapes from the egg.\(^{(10)}\)

In many Cestodes and Trematodes, the embryos are developed before the eggs are cast, and in some of the last order, they make their escape while the eggs are in the uterus.

The development of the Cestodes occurs as follows: After the disappearance of the germinative vesicle, large, transparent embryonic cells appear in the midst of the vitellus, which undergoes fissuration. These multiply by division, increasing at the expense of the vitellus, which in the tightly to the vulva of the female in this act, that they cannot disengage themselves (Siebold and Nathasmus, in Wiegmann's Arch. 1836, 1, p. 103, &c., loc. cit. 1837, 1, p. 69, &c.). With many other species of *Strongylius*, and *Ascaris*, it is not rare to find a brownish gum about the vulva, and in which there is, sometimes, the very distinct impress of the male caudal valve (Mebiis, Isia, 1851, p. 57).\(^{8}\)

\(^{(8)}\) In the genus *Mermis* formed by Dujardin, the tubular uterus, the muscular vagina, and the vulva situated far from the caudal extremity,—all remind one much of the Nematodes. The eggs of *Mermis microsoma*, like those of *Ascaris den- tata*, have long fibridated appendages (Dujardin Ann. d. Sc. Nat. 1842, XVIII. p. 153, PI. VI., and Siebold, in Wiegmann's Arch. 1843, II. p. 590); and at the caudal extremity of the males of *Mermis albicans*, nihi (Rotom. Zeit. p. 79), there are, as in most Nematodes, two horny penises.

But with *Gordius*, the structure of the genital organs is very different (see Siebold, and Dujardin, loc. cit.). In both sexes the cavity of the body is completely filled with a double genital tube, straight, and simple posteriorly, the sides of which are formed of large cells. The genital opening is always at the posterior extremity of the body. The testicular tubes of *Gordius aquaticus* contain anteriorly, cell-like bodies; but posteriorly there are others, straw-like, and which, being found among the eggs in the uterine tube, I have regarded as perfect spermatic particles. The genital opening of the male *Gordius* is between the two more or less prominent lobes of the caudal extremity, and is without copulatory organs. The simple, round, colorless eggs, are bound together at the posterior part of the uterus by an abundant substance, and are deposited in a very long row. It is this row of eggs which Léon Dujour has described as *Filaria Mariae* (Ann. d. Sc. Nat. XIV. 1823, p. 222, PI. XII. fig. 4).

\(^{1}\) See Sternstrup, Ueber den Generationswechsel, &c., 1842.

\(^{2}\) In various marine fish there is a trematode larva of a *Tetrarhynckus* (Miescher, Bericht uber die Verhältn. d. Naturforsch. Gesellschaft in Basel, 1840, p. 29), and in Wiegmann's Arch. 1841, II. p. 583), which would lead one to conclude that alternate generation exists also with the Cestodes.

\(^{8}\) [§ 117, note 9.] For many details of the reproductive organs of *Ascaris infecta*, with beautiful illustrative figures, see Leidy, A Flora and Fauna, &c., loc. cit. 4 B. Pl. VII. 14, 16, b. 19. — En.

\(^{1}\) [§ 118, note 2.] The view here suggested of the alternating generation of the Cestodes, has recently been confirmed most thoroughly by Siebold, who has treated the subject in a most comprehensive manner, in a Memoir in Siebold and Kettler's *Zeitschr. 1840*, p. 198. — En.
end they completely replace. When this has taken place, there is a mass of extremely small cells, which, being covered with a delicate epithelium, form a round or oval embryo, upon one extremity of which there are gradually formed six small horny hooks.\(^3\)

The embryos of the Acanthocephali are perhaps developed in the same manner, but they have only four hooks.\(^4\)

The Trematodes are developed exactly like the Cestodes, excepting that their oval embryos have usually ciliated epithelium, and there is an oral sucker in place of the hooks.\(^5\)

Beside this first period of development, or embryonic state, there are other more advanced or larval states, during which many Helminthes have been described and figured as separate species in the science.\(^6\)

Among these may be especially noticed two forms of the Trematodes — the cylindrical and the cercarial larvae. The first (the germinative tubes of \(\text{Baer}\)), form one of the phases of the alternate generation, and have a more or less complete organization. In the cavity of their body, germinative corpuscles are formed; these consist of a vesicular, granular substance, and resemble eggs neither by their structure nor mode of development.

These corpuscles produce larvae of a cylindrical or cercarian form, which, deprived of their tail, are changed into perfect animals which have genital organs; and thus the series of metamorphoses is terminated.\(^7\)

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\(^3\) For the embryonic development of Bothrioces-

\(^4\) As yet, with Echinorhynchus gigas alone have I succeeded in liberating the embryos from the egg by compression. The four hooks of these embryos resemble, by their form and position, those of the Cestoid embryos. It does not appear, however, that the embryos of all Echinorhynchus have the same form; Dujardin has not found them, with those of Echinorhynchus transversus, and globocaecatus (Hist. d. Helm. Pl. VII.).

\(^5\) For the embryonic development of Monostoo-

\(^6\) In this category are the genera Ceraria, Histrionicello, Eucephalus and others, which as yet have been founded only upon different species of Trematode larvae. The Helminth described by Lohland (Ann. d. Sc. Nat. VI. 1836, p. 290, PI. XVI. fig. 3) as Amphistomum ropaloides, is only a larva of a Tetranychus. The species forming the genus _Scleex_ are certainly only imperfect _Bothrioces_; and the _Grypocercus pusilus_ of Nordmann (Mier. Beitr. Helm. I. p. 101, Taf. VII. fig. 6, 7), is probably only a young _Taenia_. There may also be a doubt here, if the _Cyasulci_ can be considered as real species.

It is very probable that they are imperfect Cestodes whose genital organs are to be afterwards developed, as with _Cysticerus fasciolarii_, what _Bothrioces nodulosus_ is to _Bothrioces solidus_; see Creplin, Nov. Obscr. &c. p. 90.

The cylindric larvae of the Trematodes have been termed by Steenstrup (loc. cit. p. 90) _nurses_ (Ammen). They are yet known only as living parasitically upon Mollusca, as for instance, upon _Paludina_, _Lymnaeus_, _Planorbis_, _Ancylius_, _Scu-

\(^7\) The cylindric larvae of the Trematodes have been termed by Steenstrup (loc. cit. p. 90) _nurses_ (Ammen). They are yet known only as living parasitically upon Mollusca, as for instance, upon _Paludina_, _Lymnaeus_, _Planorbis_, _Ancylius_, _Succinea_, _Anodonta_, and _Unio_; also upon _Helix pomatia_, and _Tellina battia_, according to _Boja-

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\[\text{§ 118. THE HELMINTHES.} \quad 129\]
With the Nematodes, of which very many are viviparous, the embryos are developed within the egg in two different ways: Either the embryonics (Baez, in the Nov. Act. Acad. Leop. XIII. pt. 2, p. 570, Tab. XXX.). Those of Distomum duplicatum have simple, oval, and rigid germinative utricles (Baez, Ibid. p. 558, Tab. XXIX.). Those of Cercaria ephemer a, are also very simple, but of a cylindrical form (Siebold, in Burdach’s Phys. loc. cit. p. 187, and Steenstrup, loc. cit. p. 78, Taf. III. fig. 1-6). Those of Cercaria furcata are simple and cylindrical, but very long and endowed with quite active peristaltic motions (Baez, loc. cit. p. 629, Tab. XXXI. fig. 6). The curious animal, Leucochloridium paradoxum, consisting of only a cylindrical sac with a tail, is only a transient larva (Carus, in the Nov. Act. Acad. Leop. XVII. pt. 1, p. 55, Tab. VII.). With the slow-moving, cylindrical, orange-colored larvae of Cercaria ephemer a, there may be easily seen a mouth, a pharynx, and a simple coecal intestine (Siebold, in Burdach’s Phys. loc. cit. p. 187). Those of Cercaria echinata, are similar, but they have also two short oblique prolongations in front of the oblique canal extremity (Baez, loc. cit. p. 629, Tab. 31, fig. 7, and Steenstrup, loc. cit., p. 78, Taf. III. fig. 2-6). The germinative bodies from which Cercaria is developed, have nothing comparable to a chorion or germinative vesicle. Their larva have always a tail, which is simple (Cercaria armata, ephemer a, Distomum duplicatum, or bifurcated (Cercaria furcata), or double (Bucephalus polymorphus). The movements of this tail are very slow with Distomum duplicatum, but extremely lively and vertical with Cercaria. With Brachypalus, the two filiform tails lengthen and shorten considerably, at the same time jerking all about.

When the larvae are developed, they leave the corpses and pass into other animals to complete their final metamorphoses. Many Cercariae appear to prefer the larvae of insects whose bodies they enter by means of their cephalic hooks. In this way I have seen the Cercaria armata easily enter the larva of Ephemer a, Nemura, and Perla. By the aid of its sting it can perceive the intersegmental membrane of these larvae. Frequently it loses its tail in passing through a narrow opening it has made.

Immediately upon reaching the cavity of the body of the larva, it is surrounded by a vesicular membrane, in which the sting is rejected, and the animal enters upon its final metamorphosis. But I have a doubt whether it is there completed, for among the numerous similar parasites which I have found in the most different insects whose larvae are aquatic, as of Libellula, Agrayron, Ephemera, and Pterygonea, I have never met with one whose genital organs were in a state of advanced development.

The full development of these organs, the delicate contours of which may be seen while the parasites are in the bodies of these animals, is not perhaps attained, until the insects have been swallowed by birds and other animals,—being thereby furnished with more proper conditions for their complete formation.

Some Cercariae lose their tail and are surrounded with a capsule without leaving the Mollusks which are their first habitat. This is probably so, because these Mollusks are liable to be eaten by aquatic birds, in which these parasites may probably reach their final development. It should, however, be remarked that when these larvae become chrysalkides, their investing capsule or cyst, is a secretion from their bodies, and not a product of the animals in which they live. It is probable that very many of these larvae never attain a perfect state for, in their migrations, they fail to reach their desired and final destination.

These migrations undoubtedly occur with many Cestodes while young; at least Miescher has observed it with Taenia canina. But although we have followed these in their migrations, and the transformation of many of them into Monostomum and Distomum has been observed, and therefore the completion of their metamorphoses, yet we are but slightly informed as to their beginning by the alteration of generation.

This will be known as to the manner in which these embryos are changed into the cylindric nures. There are now only two isolated facts throwing light upon this point. According to my own observations (Wiegmann’s Arch. 1835, I. p. 76, Taf. I), each embryo of Monostomum mutabile contains a germinative tube, which, at the death of the embryo, is freed and quite resembles the nurse of Cercaria echinata. I have also observed in the embryos of Amphistomum subclavatum a tubular body, but I could not satisfy myself of its germinative nature. According to Steenstrup (loc. cit. p. 99), there is an animal like a Parasarcia, and probably an embryo of a Distomum, living in Muscles, and which finally is deprived of its epithelium, and changed into the rigid, germinative tube of Distomum duplicatum; see upon this, my Jahresbericht in Wiegmann’s Arch. 1843, II. p. 300.8

* [§ 118, note 7] In this connection should be noticed the remarkable phenomena of reproduction with Gyrodactylus as recently observed by Siebold (Siebold and Kittler’s Zeitschr. I. 1819, p. 346). Individuals are here developed viviparously as in the so-called alternating genera, and Siebold has observed a mother in which was a daughter and in this last a grand-daughter, the series being therefore three-fold. These viviparous individuals contain no sexual organs proper, but the new individual is developed out of a group of cells situated within the body. The whole reproductive conditions which Siebold has detailed with his usual care appear to me to closely resemble those of the viviparous Aphides which I have recently investigated; and I believe this mode of reproduction to be only a peculiar form of generility or budding suited to some ulterior, economical purpose of the animal’s life. On a future page I shall speak more fully on this point and attempt to show that the whole act of phenomena known under the name of “Alternation of Generations” is, when divested of its paraphernalia, only a kind of Generility.

See also for further details on that curious animal Leucochloridium paradoxum, Piper, in Wiegmann’s Arch. 1851, I. p. 535, but especially Siebold, in Siebold and Kittler’s Zeitschr. IV. 1853, p. 425, Taf. XVI. B. This last-named observer has shown that this animal form is only a
nic cells present the same successive phases as in the Cestodes and Tremato
des, without the appropriated vitellus undergoing any segmentation; or,
the whole vitellus after a complete segmentation, is changed into an em-
byro.
In both cases, the embryo has the parent's form. A muscular aestha-
gus and straight intestine appear in its body in the midst of the refuse
vitelline granules; and thus the young animal attains its perfect state by
simple increase and by the development of its genital organs, but without
any metamorphosis.
From the few observations hitherto made upon the development of the
Gordiacei, it appears that the embryos exactly resemble the parents.

§ 119. THE HELMINTHES.

1 Kolliker was the first to call the attention to
these two types of development with the Nema-
todes (Müller's Arch. 1843, p. 68, Taf. VI. VII.).
With Ascaris dentata, Ozyuris ambigua, and
Curling, Bowditch, Boston Farre, 131
ject which
embryonic
are formed in the vitellus without its fissuration. But
there is a complete segmentation with Ascaris nigrocepa,
accoina, vacina, vacinului, labata, and brevicaudata, Strongylus auricu-
taria, dentatus, Filaria inficlo-caudata, rigida, and
Sphaerularia bombi. After I had already
noticed this vitelline segmentation with the Ne-
matozes (Burdach's Phys. loc. cit. p. 211), which
Bagge (Dissert. loc. cit.) described very fully, Kolliker (loc. cit.) attempted to reconcile it with
the cell-theory, by regarding the cells which appear in the segmented, vitelline globules, as
the embryonic cells, and in the multiplications of which by segmentation, the enveloping vitellus
participates.
2 It appears that, as with the Trematozes, so in
the Nematozes, a migration of the young precedes
their complete development.
In the tissues of the most different insects and vertebrates, there are found small Nematozes
without genital organs, and contained in a cyst. They could not get there except by a migration,
and they cannot attain the full development of
their genital organs or their bodies in general,
except through a transplantaion upon other ani-
mal species; exactly as occurs with the trematodal larvae.
(See the observations of Cregling and myself upon the sexless Trematozes, in Wiegmann's Arch.
1838, I. p. 302, 373.)

The Trichina spiralis of man is undoubtedly an
encysted and imperfect form of one of the Nema-
todes, and in which one may seek in vain for gen-
itual organs. Some of these Nematozes appear to
increase in their cysts without their genital organs
being developed in the same proportion. Thus, the
Filaria picusite are sometimes found very large,
while their genital organs are very little developed:
and these last do not probably attain their perfect
state, until, as with Bothriocephalus solidus, these worms have passed into other animals.
For the same reason, I agree with Steenstrup (loc. cit.
p. 113), who doubts that the Filaria picusite
become, as Mischier has affirmed (loc. cit. p. 26),
a globular capsule out of which there afterward
appears an animal at first resembling a Trematoze,
but which finally becomes a Tetrarhyncus.

pl. VI. fig. 15, 16) upon Merms nirescens,
researches which I have been able thoroughly to
confirm.

kind of nurse of a Distomum, containing peculiar
germ-bodies which are developed into Distomum.
But the most important result obtained is that all
Distomum are not developed by means of a cer-
carian, larval stage,—the economy of some making it
seemingly requisite that the developmental pro-
cess should be more direct. — En.
[§ 119, note 2.] In regard to Trichina spi-
rals, the various researches upon its structure,
in England and America, would show that it is
a true animal having genital organs. The fol-

lowing are some of the references upon this sub-
ject: Owen, London Med. Gaz. April and Decem-
ber, 1853, or Transact. Zool. Soc. London, IV., or
Cyclop. Anat. and Phys. Art. Entozoa; Wood,
London Med. Gaz. May, 1853; Farre, Phil. De-
Assoc. for the Advancement of Sc. 1835; Knorr, Edinb.
Med. and Surg. Journ. 1836, XLVI. p. 86; Hodg-
kin, Lect. on Morbid Anat. of Serous and Muscus
Membranes, I. p. 212; Curling, London Med.
Gaz. February, 1836; Bowditch, Boston Med. and
Surg. Journ. April, 1842; Luschka, Siebold and
Kolliker's Zeitsch. III. 1851, p. 69, Taf. III., and
Gairdner, Edinb. Monthly Journ. of Sc. May,
1853. The subject is one that deserves especial
attention from Helminthologists. — En.
[§ 119, note 3.] Grube (Wiegmann's Arch.
für Naturgesch. 1849, p. 355) and Leidy (Proc.
Acad. Sc. Philad. V. 1850, p. 93) have observed
the development of Gordius. It corresponds
precisely closely with that of Ascaris as described
by Bagge; but the embryo on escaping from the egg
is annulose and tentaculated, and differs much
from the adult form. Nothing is known of the
history of the animal between these two conditions.
— En.
BOOK SIXTH.

TURBELLARIA.

CLASSIFICATION.

§ 120.

The Turbellaria receive their name from the ciliated epithelium, which covers their whole body. Their flattened, or cylindrical, non-articulated body, is formed of a loose parenchyma, in which lie hid the viscera. The nervous system appears very little developed, and when visible, consists only of a cervical ganglion, from which there never extends a ventral cord. The multiramose intestinal canal is always without an anus. The genital organs are either very much developed, or entirely absent. In the first case, these animals are always hermaphrodites, and have copulatory organs.

The Turbellaria have been shifted from one zoological system to another, but their organization has sufficient peculiarities to entitle them to a special class by themselves.

Ehrenberg was the first to found the group Turbellaria; but he has included therein many different animals; and we are, therefore, indebted to Orsted, for a late revision of this group.

ORDER I. Rhabdocoëli.

The alimentary canal is simple and cylindrical; the oesophagus, non-protractile; locomotion, mostly natatory.

Genera: Vortex, Derostomum, Gyatrix, Strongylostomum, Mesostomum, Typhloplana, Macrostomum, Microstomum.

ORDER II. Dendrocoëli.

Intestinal canal dendritically ramified; oesophagus completely protractile; locomotion reptatory.

1 I cannot here omit the question, if these small sexless Turbellaria, as for example, Derostomum, and Microstomum, really constitute distinct genera, and if they are not rather the larvae of other inferior animals.

BIBLIOGRAPHY.


ADDITIONAL BIBLIOGRAPHY.

Beside the writings referred to in my notes, see the following:
M. S. Schultzze. Über die Microstomeen, eine Familie der Turbellarian, in Wiegmann's Arch. 1849, p. 280, Taf. VI.
Beiträge zur Naturgeschichte der Turbellarien. 1851.— Er.

CHAPTER I.

CUTANEOUS SYSTEM.

§ 121.

The whole body of the Turbellaria is covered with ciliated epithelium, under which lies a loose cellular parenchyma. In this parenchyma, and directly beneath the epithelium, there are found, in many species, particular cell-like bodies, which sometimes remind one of the netting organs of certain zoophytes, and sometimes exactly resemble the prehensile organs.
of the arms of Polyps.\(^1\) These bodies contain six or eight, or even more, staff-like, colorless corpuscles, which are parallelly arranged side by side, or curled a little spirally. With their further development, the envelope disappears, and they then remain free under the skin, but sometimes projecting through it.\(^2\)

**CHAPTER II.**

**MUSCULAR SYSTEM AND LOCOMOTIVE ORGANS.**

\(\S\) 122.

Although their parenchyma is extremely contractile, yet the Turbellaria have only a very feebly-developed muscular system.

In many small species of the Rhabdocoelii, the parenchymal muscles may be made out; and in the larger _Planariae_, when the muscles are visible, their fibres appear unstriated.

The small Rhabdocoelii swim by means of their ciliated epithelium, like many Infusoria, their bodies revolving on its longitudinal axis; while the flattened Dendrocoelii crawl along like the Gasteropoda.\(^1\) Many larger species of the first order,\(^2\) appear to float from place to place by means of their epithelium, thus really neither creeping nor swimming.

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1 With _Microstomum lineare_, Orsted, these prehensile organs so closely resemble those of _Hydra_ that they need not be described. According to Orsted they are urino-shaped glands in the centre of which are parabolic bodies which are constantly in motion (loc. cit. p. 73, Taf. II. fig. 15). But had he pressed these organs between two plates of glass, he would have seen the protruding filament, together with its double hooks.

2 I have seen these corpuscles protruding through the lateral border of the body of _Planaria lactea_. In the dorsal papillae of _Thysanozoon Diesingii_, a part of these corpuscles are contained in cells; but the others are free and often protrude through the skin. With _Mesostomum Ehrenbergii_, and _rostratum_, they are arranged in rows in the anterior half of the body, forming striae, which quickly catch the attention. Orsted has taken these corpuscles for as many muscular columns (loc. cit. p. 70, Taf. II. fig. 29, 37). The spines which, according to him (loc. cit. p. 72, Taf. II. fig. 29, 34) cover the entire surface of _Macrostomum hystrix_, are probably of the same nature, as may also be said of the delicate short bristles found everywhere under the skin of _Derostomum leucotypus_, _Bugis._

Quaestiones, in his monograph on marine _Planariae_ (Ann. d. Sc. Nat. IV. 1845, p. 146, Pl. VIII. fig. 9, 10), also mentions various formations which, partly as spines, partly as netting organs, are found in the skin of certain Dendrocoelii.

1 The mode of locomotion by which these animals move over solid bodies, or upon the surface of the water, has not yet been satisfactorily explained. The ciliated epithelium cannot here be the principal agent. According to Schulter, loc. cit. p. 22, the staff-like corpuscles projecting from the back of these animals, and which he terms bristles, are used as ears.

According to Mertens (Mém. de l'Acad. de St. Petersbourg, tene, sér. II. 1833, p. 5), _Planaria tikcaniodes_ moves by means of the protruded lobes of its pharynx.

2 For example, _Mesostomum_.

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§§ 123, 124. THE TURBELLARIA.

CHAPTERS III. AND IV.

NERVOUS SYSTEM AND ORGANS OF SENSE.

§ 123.

The nervous system with the Turbellaria, is quite indistinct, for it has not yet been observed in the small species, and in the larger ones its disposition is yet doubtful. A double ganglion in the cervical region appears to form its central part, and from this nerves pass off in different directions.\(^1\)

§ 124.

Among the organs of sense, those of vision are the most developed with very many species.

The red, brown, or black spots on the anterior extremity, two or more in number, are not always simple pigment cells,\(^2\) but may be regarded as eyes, for they have a cornea,—a light-refracting body surrounded with pigment, and a nerve-bulb.\(^3\)

As to the sense of touch, no special tactile organs have yet been found, but the whole surface reacts sensitively from the lightest contact; and this sensibility appears particularly prominent at the anterior extremity, which, with many Dendrocoelii, is furnished with lobular and other appendages.\(^4\)

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\(^1\) Ehrenberg, has seen two disconnected ganglia with Planaria lactea (Abh. d. Berl. Akad. 1836, p. 243). With other Dendrocoeli, as with Planocera saragossicola, and yellowida, these two ganglia are blended into one; at least, the organ which Mertens has here described as a heart, has exactly the appearance of two united ganglia (loc. cit. Tab. I. fig. 6, Tab. II. fig. 3, 3, or bis 1-36, Tab. IX. fig. 3, c. n.). The light pulsations which this author affirms to have here observed, are perhaps, as Ehrenberg has supposed (loc. cit. p. 244), due to the contractions of neighboring organs. According to Schulze (loc. cit. p. 30), with Planaria torca, the double central ganglion gives off two nerves, which pass backwards on both sides of the intestine.

This double ganglion, situated in the cervical region, and the nervous filaments which it gives off, have been demonstrated by Quadrelages (loc. cit. p. 172, Pl. IV.—VI).

1 Most commonly there are two eye-dots. With Planocera, and Leptophlana, there are many which are grouped together, and with Polycelis nigra, the whole anterior part of the body is covered with them. In many small species, they appear to be of a simple pigmented nature.

2 With Planaria lactea, there is, between the cornea-like bulging of the skin, and a semilunar, pigment layer, a small, conical, transparent body, corresponding exactly to a crystalline lens; see Ehrenberg, loc. cit. p. 243, and Schulze, loc. cit.

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\(^2\) [§ 124, note 2.] See also Leidy (Proc. Acad. Nat. Sc. Philad. III. 1845, p. 248) on the eye-specks of Phacocata gracilis, a sub-genus made by him from Planaria, and Schmidt (Die Rhabdocoeli Seriudewürmer, &c., p. 7, and Neue Beiträge zur Naturgesch. der Würmer, &c., p. 11). Both of these observers agree in considering these parts in p. 37. With Monocelis, these organs are very remarkable, being composed of two eyes blended into one, and the simple and spherical ball of the eye is filled, according to Orsted, with a transparent vitreous body, in which two conical crystalline lenses are buried with their apices pointing inwards (loc. cit. p. 6, 56, Tab. I. fig. 1, 2, and in the text, fig. 10). Orsted has distinctly seen two optic nerves passing laterally to this organ. It is quite remarkable that with one of the three known species, the Monocelis unipunctata, the eye is entirely without pigment. Ehrenberg affirms that he has observed with Polycelis, many starlike ganglia in the middle of the anterior part of the body, which are for the long row of eye-dots (loc. cit. p. 245).

3 For the eyes of the marine Planaria, see also Quadrelages, loc. cit. p. 178, Pl. III. The organ which with Monocelis has been taken for an eye by Orsted, appears to be, according to the researches of Frey and Leuckart (Beitr. p. 59, Tab. I. fig. 15), an auditory organ. That which Orsted regarded a vitreous body, is an otolyte, and his two crystalline lenses, are two semicircular prolongations attached loop-like to the otolyte. Frey and Leuckart are also convinced that Convia ta paradoxa Orst., has a single auditory capsule, situated on the median line of the cervical region, and containing an otolyte which floats in a bluish-colored fluid; see Beitr. loc. cit. p. 82, Tab. I. fig. 17.\(^5\)

3 There are contractile and antenniform appendages as visual organs. Schmidt has often failed to find anything like an otolyte; but, on the other hand, has often found with various Derastosum a complete visual apparatus. This point, therefore, is still unsettled, unless, as Schmidt ingeniously suggests, it may be that one organ serves the functions of two separate senses. — Ed.
CHAPTER V.
DIGESTIVE APPARATUS.

§ 125.

With the two orders of Turbellaria, this apparatus is formed upon very different types. But in both orders, the location of the mouth varies so much, that it serves as the basis of genera, according as it is at the anterior extremity, or a little behind it,—or, at the middle of the belly, or a little behind that also. The walls of the intestinal canal are always intimately blended with the parenchyma of the body.

With the Rhabdocoeli, the mouth leads to a muscular oesophagus, which is either an annular sphincter, or a longer or shorter tube, but which, in no case, can be everted from the mouth. The intestinal canal is a simple caecum extending from the oesophagus to the posterior extremity; but with those species which have the mouth situated more or less posteriorly, it stretches forward as a coecum to the anterior portion of the body. (1) With the Dendrocoeli the mouth opens into a large throat, containing a protractile and very movable deglutitory organ (Pharynx).

This organ, which can be protruded entirely out of the throat while the animal is eating, is either a tube composed of longitudinal and transverse muscles, or a collection of lobular and ramified tentacles circularly arranged about the mouth.

Its base is prolonged into the proper intestine, whose dendritic ramifications extend over the whole body. (2) Scarcely a trace of salivary or hepatic organs have here been found with these animals. (3)

ages on the anterior part of the body of Planaria tentaculata, and Eurypleta cornuta, and upon the neck of Planocera. With the last, they support a part of the eye discs.

1 The mouth and cylindrical oesophagus of Gyraurus hermaphroditus, and Vortix trunca, are at the cephalic extremity (Ehrenberg, Abhandl. d. Berl. Akad. 1835, p. 178, Taf. I. fig. 2, 3). But the mouth and annular oesophagus of Derostomum is situated just back of this extremity, into which, however, the coecal intestine extends. The oesophagus is also annular with Mesostomum, and Typhlops hir. In the first, the mouth is at the middle of the ventral surface; and in the last, a little behind this point, while the intestine projects only far into the anterior extremity (Brodie, loc. cit. Taf. II. fig. 26, 31, and Focke, loc. cit. Taf. XVIII.).

2 The genus Planaria has become famous for its movable organ of deglutition, which, being separated from the body, still continues for a while to swallow all presented to its mouth (Eber, loc. cit. p.

716, Tab. XXXIII. fig. 8-11, and Dugès, loc. cit. XV. p. 152, Pl. IV. fig. 18, 19).

The large and plicated oesophagus of Planaria tremelaria, constitutes the transition to the tentacular form of the deglutitory organs (Dugès, loc. cit. XV. Pl. IV. fig. 20, 31). Fully ramified tentacles are found with Planocera sargassicolor, pellicuda, and Leptoplana lichenoides. When collected in the throat, they present exactly the aspect of a ramified intestine (Mertens, loc. cit. Taf. I. fig. 2, 3, 6, Taf. II. fig. 3, 4, and the Isis, 1836, Taf. IX. fig. 3, b, 3, c). The ramified intestine of many Dendrocoeli has been figured by Bayer, Dugès, and Mertens, in their works already cited. (1) Focke (loc. cit. p. 196, Taf. XVII. fig. 11, c. f.) is inclined to regard as salivary and hepatic organs, two large lateral vesicles, and a glandular organ which he has discovered near the oesophagus and intestine of Mesostomum Ehrenbergi; but he himself admits that this view is not yet well founded. (3)

* [ § 125, note 2.] With Phagocata (Planaria) gracilis, Leidy (Proceed. Acad. Nat. Sc. Phila. Ill. 1848, p. 248) found, instead of a single sucker, twenty-three, in the full-grown animal. These are all protruded when the animal feels, but when not in use, are closely packed together within the animal. They all connect separately with portions of the dendritic alimentary cavity.— Ed.

† [ § 125, note 3.] Will (Müller's Arch. 1848, p. 506) has shown that the brownish layer covering the whole extent of the intestine of Planaria is composed of hepatic glands (Dendrocoelum lasc- teum, Planaria torquata, niger).— Ed.
CHAPTERS VI. AND VII.

CIRCULATORY AND RESPIRATORY SYSTEMS.

§ 126.

As yet, only a very imperfect vascular system has been observed in the parenchyma of these animals. With the Dendrocoeli, there are constantly two principal vessels, extending along each side of the body, which give off many lateral branches and anastomose together at their two extremities.

This system has no central heart-like organ, and the walls of the vessels not being contractile, the circulation is probably effected through the general contractions of the body. The contained homogeneous and colorless liquid ought therefore to be considered as a nutritive fluid.

With the Rhabdocoeli, the disposition is different. In many there are one or two vessels which traverse the body and loop at its extremities, without either giving off branches or diminishing in size. The movement of their colorless liquid is due to isolated vibratile lobules situated here and there in the vessels.

This organization reminds one more of an aquiferous than a sanguineous system.

Special respiratory organs are here wholly absent, if we do not regard as such the aquiferous system just mentioned. There remains, therefore, only the conjecture that the ciliary epithelium upon the entire surface of the body is subservient to a general cutaneous respiration, by constantly bringing the water in contact with the skin.

1 Dugès has described and figured very completely the vascular system of Planaria (loc. cit. XV, p. 160, Pl. V. fig. 1, 2, XXI. p. 85, Pl. II. fig. 24, 25). The cordiform organ which Mertens (loc. cit. p. 12, Taf. I. fig. 6, Taf. II. fig. 3) refers to the vascular system of Planocera sargassica and pellicula, is probably, as seen above, the central part of the nervous system. Dugès is the only observer who affirms to have seen with the Dendrocoeli proper movements of the vessels; while Mertens, Ehrenberg (Abhandl. d. Berl. Akad. loc. cit. p. 243), Schultze (loc. cit. p. 18), and Gras ted (loc. cit. p. 10), have observed only the contrary.

2 With Derostomum leucops, Dug., I have seen two intertwined vessels of equal size throughout, extending from the caudal extremity to the head where they form a simple loop. At the caudal extremity, they approach so near to the cutaneous surface that it is impossible to decide whether they terminate there by a loop, or open externally. Ehrenberg (Abhandl. d. Berl. Akad. loc. cit. p. 178, Taf. I. fig. 2) has figured two pairs of such vessels with Gyrautra hernaphroditus, and which loop at the posterior extremity, but in front terminate indistinctly. The trembling in the interior of these vessels observed by Ehrenberg, indicates certainly the presence of vibratile lobules, and which, Grasted (loc. cit. p. 17, Taf. III. fig. 48) has distinctly found in the vessels of Mesostomum Ehrenbergii, while Focke (loc. cit. p. 200) could see only their effects. These are the very vessels which this author supposes connect with the pharynx; but this is not so according to my own observations.*

* § 126, note 2.] See for these two systems, Schmidt, Die Rhabdoc, Stradew., &c., p. 11, and

12*
THE TURBELLARIA. §§ 127, 128.

CHAPTER VIII.

ORGANS OF SECRETION.

§ 127.

No special organs of secretion have yet been found with the Turbellaria, although these animals, and especially the Dendrocoelid, secrete from their cutaneous surface an extraordinary quantity of mucus.1

CHAPTER IX.

ORGANS OF GENERATION.

§ 128.

The Turbellaria propagate by transverse fissuration, and by the means of genital organs.

In the smaller Rhabdocoelid, which have no trace of genital organs, the transverse fissuration is the rule.2 It is, however, probable that at certain epochs of their lives, genital organs are developed, and therefore, that they multiply also by eggs.3

With both the larger Rhabdocoelid, and the Dendrocoelid, the genital and copulatory organs of both sexes are situated upon one and the same individual, so that they are capable of self-impregnation; but there is generally a reciprocal copulation.4 This genital apparatus is very complex, and as the contents of its various parts have not yet been subjected to a careful analysis, it is not positively certain that the right interpretation of them is given.

1 It is yet undecided whether the subcutaneous cell-like bodies of the Dendrocoelid have any relation to this secretion.

Dugès (Ann. d. Sc. Nat. XV. p. 169, Pl. V. fig. 15) has observed a voluntary transverse fissuration with Derostomum lineare. I have been able to follow the very regular fissuration of Microstomum lineare, where each unseparated half of the body began to halve again, and then these four pieces also each divided, and so finally the body appeared worked by seven transverse furrows, into eight divisions.

I must here remark, to prevent an error, that I. contrary to Orsted (loc. cit. p. 75), regard these two mentioned species as distinct; for Derostomum lineare, Dugès, is without the reddish brown eye-dots and the prehenile organs, which are found with Microstomum lineare, Orsted. The wonderful reproductive power of the sexless Planariae, and which can be multiplied artificially by divisions in all directions, would lead us to infer that they propagate also from accidental divisions, to which their vulnerable nature is constantly exposed.5

2 Orsted (loc. cit. p. 21, Taf. III. fig. 55) and Ehrenberg (Abhandl. d. Berl. Akad. loc. cit. p. 178, Taf. I. fig. 2, 3) affirm to have seen ovaries, testicles, copulatory organs, and eggs with Microstomum lineare, and many other allied Rhabdocoelid, such as Gyralect, Fortex, and Strongylostomum; but the details they have given are too imperfect to allow definite opinions upon this organization. I must here ask if these animals have not been confounded with the sexless larvae which multiply by fissuration like those of Medusae.

3Collision has often been observed with Planaria and Mesostomum, and has been figured by Baer, Dugès, and Focke.

4 See Laidy (loc. cit.); he found that with Phagocata (Planaria) gracilis, this subdivision could not be carried successfully beyond three or four parts.—Eb.
THE TURBELLARIA.

The following are the parts usually found: an ovary or organ of viteleline secretion, which is double, and, extending into the parenchyma of the body, opens by a common excretory duct into a large cavity,—a vagina or oviduct; a double testicle sends its seminal liquid, full of filamentososs and motionless spermatid particles, into the seminal vesicle through two tortuous vasa deferentia; to this seminal vesicle is attached a very erectile penis, situated by the side of the vagina. There is a common genital opening, situated always behind the mouth, for the protrusion of this penis and the escape of the eggs.

With Planaria, there are, beside, two special, hollow organs, with narrow excretory ducts, which open into the vagina. Of these, one very probably secretes the envelope of the egg, while the other serves as a Receptaculum seminis.

The embryonic development of the Turbellaria is yet unknown except with the Planariae.

It differs wholly from anything yet known with other Invertebrates. Many of these embryos are developed, always simultaneously, in one large egg; but it is impossible at first to determine their number, since

4 See, for the genital organs of Mesostomum Ehrenbergii, Focke (loc. cit.); for those of Planaecera, and Leptogiana, Mertens (loc. cit.); and for those of Derostomum, and Planaria, Dugès, Baer, and Orsted (loc. cit.). But the interpretation here given of the different parts of these organs must be much changed. For, to speak here only of the genus Planaria, what Baer has regarded as the ovaries and ovdrtucts, are certainly the two testicles with their vasa deferentia, since I have always found them filled with spermatid particles (loc. cit. Tab. XXIII. fig. 18, a. b.). The two seminal canals open into a hollow, flask-shaped body like a Vesicula seminalis or a Ductus ejaculatarii, the neck of which is continuous with a very contractile and erectile tube (Penis). This penis is in a cavity separated by a septum from the large vulva, with which, however, it communicates by a special orifice, and consequently can be protruded through the common genital opening. There is, besides the intestinal canal, another ramified organ in the body of Planaria, and which very probably is an ovary, or at least a vitellocencinating organ. But its canal contains only simple vesicular bodies, which have no germinative vesicles. The canal which Dugès (loc. cit. XV. Pl. V. fig. 4, b.) has taken for an oviduct, belongs probably to the ramifications of this organ. The other two organs which this author (ibid. Pl. V. fig. 4, 5, e.) has described as Vesicule copulatrice or réservoir du sperme et des œufs, do not appear to me to exist in all Planariae. They consist of two hollow, pyriform organs, not blended together as Dugès has figured them, but distinct; one opens by a long, and the other by a shorter canal, into spermatid particles of the Planariae is little understood. They probably have not a hair-like form as mentioned in the preceding note, but are Cercariolike; see Költiker, loc. cit., Quattrefages, loc. cit. Pl. VIII. fig. 5-9, and Schmidt, Die Rhabdocoel. Strudelwünder, &c., p. 18; this author, however, describes those of Opistomum pallidum as somewhat different, there being a filament beyond the head (Taf. V. fig. 24).—Ed.

§ 129.

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their chorion contains only loosely-arranged vitelline cells, among which there is seen no trace of one or more germinative vesicles. The vitelline cells always contain, besides a finely-granular albuminous substance, a round nucleus which has a nucleolus. Both the nucleus and the granular substance are shifted from one side to the other of the cell by the very remarkable peristaltic movements of the cell-membrane. After a time, these movements cease, the cell-membrane disappears, and the contents mix with those of other cells which have been affected in the same way: by these means, little collections of vitelline substance here and there are formed, which increase by the addition of other cells, — and finally are transformed into roundish, nicely-defined embryos which become covered with ciliated epithelium. From this time the embryos do not increase as before by the external fusion of cells, but there is a muscular, discoid œsophagus formed upon their periphery, and through this the remaining cells are ingested and assimilated within the animal.

Still later, the embryo, hitherto spherical, becomes flat and elongated at two opposite points; — ultimately, and upon the appearance of the eye-specks, it assumes exactly the form of the adult Planariae.

The size of the young Planariae depends upon the number of embryos developed in the same egg, for the smaller this number, the larger the embryos at the time of their hatching, and vice versa.

The cause regulating the number of embryos in an egg is yet unknown. * (1)

The remarkable movements of the vitelline cells in the eggs of the Planariae, and which I was the first to observe, have since been confirmed by Kolliker, with Planaria lactea; see Witschiu's Arch. 1846, I. p. 291, Taf. X. I am unable to say whether or not the spontaneous movements observed by Quatrefages (loc. cit. p. 160; Pl. VII. fig. 6-8) upon the larger portions of the vitellus of Polyceles pullulus while in the oviducts, are of the same nature; this naturalist himself supposes that these portions were the embryos of this Planariae.*

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* See my details upon this subject in the Bericht, uber die Verhandl. d. Berl. Akad. 1841, p. 83. During the development of Planaria, one can, after a while, ascertain the number of vitelline cells assimilated by fusion and dephization, by counting their nuclei which are easily seen in the parenchyma of the body. According to Focke (loc. cit. p. 291), the eye-specks, and the œsophagus are developed very early in the young Mesostomum Ehrenbergii; — a species with which each egg contains a single embryo only, and which is developed while the egg is in the uterus.

† [End of § 129.] Recent embryological studies have thrown some light upon this point — the alleged plurality of embryos in a single egg. The so-called egg in these cases is almost undoubtedly an ovarian sac, in which are developed many germs; some of these germs may perish, and the fewness of those remaining would give the appearance of an egg with many germs. — Ed.

§ 129. The development of Planaria has been also observed by Schmidt. Die Rhabdoc. Strudelwürmer, &c., p. 17; by Agassiz (Proc. Amer. Assoc. Advancem. of Sc. 2d meeting, 1849, p. 438), who made the interesting observation that the Infusoria-genera, Kolpoda and Paramecium, are only larvae of Planaria; by Girard (Ibid. p. 398), and by Muller (Muller's Arch. 1850, p. 485). Muller has here some interesting remarks on the relations of the study of these forms to the class Infusoria. — Ed.
§ 130. THE ROTATORIA.

BOOK SEVENTH.

ROTATORIA.

CLASSIFICATION.

§ 130.

The body of the Rotatoria is covered with a smooth, hard epidermis, and, from transverse incisions, at least at its posterior portion, usually appears articulated; while its anterior portion has vibratory retractile parts—the so-called rotatory organs. The very indistinct nervous system is almost wholly comprised in a cervical ganglionic mass. The fully-developed digestive canal lies in the large cavity of the body, and its anterior portion is provided with masticatory organs, while posteriorly, it terminates in an anus. Female genital organs alone have as yet been found with certainty.

No one would deny that the Rotatoria, whose organization is so high, ought to be separated from the Infusoria, whose structure is scarcely advanced above that of a simple cell-nature. One can be in doubt only as to their other and proper place in the animal kingdom;—whether, with Burmeister, they are to be placed among the Crustacea; or with Wiegmann, Wagner, Milne Edwards, Berthold, and others, among the Worms. But the choice here between these two classes will not be difficult, for, as will soon be shown, they differ widely from the Crustacea. Aside from the absence of a ventral cord and of striated muscular fibres, these animals have vibratile organs upon the surface of their body, as well as upon their respiratory and digestive organs—a structure not found with the Crustacea, nor with the Arthropoda in general. Their development is non-metamorphic, and they do not have articulated feet when they escape from the egg; while the Crustacea, and even those which, from a retrograde metamorphosis, become vermiform, have at least three pairs of articulated legs when hatched. On the other hand, they have, in common with most worms, an articulated body, internal and external vibratile organs, absence of a ventral cord, and, with all, the want of articulated feet.

Although the uniformity of their organization does not admit of these animals being divided into orders, they can at least be considered as a separate class in the great section of Worms.
THE ROTATORIA. § 131.

Family: Monotrocha.
Genera: Ptygura, Ichthydium, Chaetonotus, Oecistes, Conochilus.

Family: Schizotrocha.
Genera: Megalotrocha, Tubicolaria, Stephanoceros, Lacinularia, Melicerta, Floscularia.

Family: Polytrocha.

Family: Zygotrocha.
Genera: Rotifer, Actinurus, Philodina, Noteus, Anuraea, Brachionus.

BIBLIOGRAPHY.
See the works already cited under Infusoria.

ADDITIONAL BIBLIOGRAPHY.
Besides the writings of Brightwell, Huxley, Leydig, and others, quoted in my notes, see the following:
See also the new edition of Pritchard's Infusoria, given under Book first. — Ed.

CHAPTER I.

CUTANEOUS SYSTEM.

§ 131.

Nearly all the Rotatoria are covered with a smooth, hard skin, which is thrown into folds by the contractions of the subcutaneous parenchyma; at the anterior extremity only, it is very delicate, and covered with vibratile organs, which also move to and fro with the parenchyma. With many,

1 With Chaetonotus, and Philodina aculeata, the structure of the skin is quite different from this; for its surface bristles with stiff points and spines. With Noteus, and Anuraea, there are species whose tesselated skin is roughened by immeasurable granulations.
the annular sulcations of the skin, partial, or over its whole extent, give
the body an articulated aspect. Many others have a skin so hard and
stiff, as to be like a carapace.

CHAPTER II.

MUSCULAR SYSTEM AND LOCOMOTIVE ORGANS.

§ 132.

The muscular system of the Rotatoria is quite distinct in many parts of
the body. There can at once be observed, distinctly separated from the
general parenchyma, unstriated muscles, of which some are transversely
annular, and many others narrow and longitudinal. The first, subcuta-
neous and widely separated from each other, are usually upon the borders
of the segments of the body. The second, divisible into dorsal, ventral and
lateral portions, arise from the internal surface of the skin, and are inserted
at the cephalic or opposite extremity.

The posterior extremity of those species which move freely, has two stiff
points of variable length, which are moved as tentacles by two cylindrical,
or clavate, caudal muscles. Some have long, movable bristles or pedicles,
by which they row along or move by quick leaps.

§ 133.

The prominent characteristic of the Rotatoria is the retractile, vibratile
apparatus at their cephalic extremity, known as the rotatory organs. By
these, they swim freely about, revolving upon their axis, or, when at rest,
produce vortex-like motions of the water. The form, number, and arrange-
ment of these organs varies much according to the genera, and may be
used even to characterize families.

The rotatory organ is either single, double, or multiple. Often it con-
stitutes of a disc, supported by a pedicle of variable length, upon whose bor-
ders are successive rows of regularly-arranged cilia, the motion of which
gives the appearance of rotation to the disc itself. This apparent motion

2 With Conochilus, Megalotrocha, Lacinula-
ria, Brachionus, Notecus, Squamella, Notom-
mata, and Stephanops, the tail is transversely
marked or articulated. With many species of Hy-
datina, Rotifer, Philodina, Actinurus, and Esop-
hora, not only the caudal extremity, but the whole
body, is regularly segmented, and capable, espe-
cially at the posterior extremity, of being intussus-
cepted or drawn out, like a telescope.

3 A solid carapace, like the shell of Daphnia, is
found with Brachionus, Anuraec, Notecus, Salpi-
na and Euchlanis.

1 The muscles are smooth when at rest, but when
contracted, they appear more or less distinctly pla-
cated transversely. The assertion of Ehrenberg
is therefore remarkable, that the longitudinal mus-

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contracted, they appear more or less distinctly pla-
cated transversely. The assertion of Ehrenberg
is therefore remarkable, that the longitudinal mus-

2 For the muscles of the Rotatoria in general, see
Ehrenberg, loc. cit. and his description of the Hy-
datina senta, in the Abhandl. d. Berl. Akad. 1830,

3 Many Rotatoria use their caudal pincers as a
fleskern when creeping along. Philodina moves
along in a leech-like manner, using its mouth and
tail as suckers. Polycarpa has many bundles of
bristles upon the sides of its body, which it uses as
oars. Triarthra has under the throat and at the
posterior extremity of the body, long stiff bristles,
articulated with the body, and by which these ani-
mal can leap like a flea.

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articulated with the body, and by which these ani-
mal can leap like a flea.
is quite remarkable with those species whose single or double disc is not crenulate, but entire. With those whose organs are more numerous, but smaller, this appearance is not observed.

With *Flocculina*, and *Stephanoceros*, the rotary organs have quite a different form. With the first, there are five or six button-like processes about the mouth, covered with very long bristles; these bristles produce usually but very feeble motions, and rarely give rise to vortexes. But *Stephanoceros* reminds one much of the Bryozoa, for its rotary apparatus consists of five tentacle-like processes covered with vibratile cilia. The rotary organs differ, moreover, from the ordinary vibratile cilia of epithelium, in being under the animal's control,—that is, moved or kept at rest, at will.

**CHAPTERS III. AND IV.**

**NERVOUS SYSTEM AND ORGANS OF SENSE.**

§ 134.

Notwithstanding the transparency of the Rotatoria, and the distinctness with which their organs are separated from each other, yet their nervous system has not yet been made out with certainty, for their bodies are so small that their peripheric nerves elude the microscope, and their principal nerves and ganglia cannot be distinguished from the muscular fasciculi, the ligaments, and the contractile parenchyma of the body.

It appears certain, however, that in all, there is, as a nervous centre, a group of cervical ganglia, from which pass off threads in various directions.

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1 *Conochilus*, *Philodina*, and *Actinura*.
2 *Hydatina*, *Notommata*, *Syncheta*, and *Diglena*.
3 See Ehrenberg, Die Infusionsthierchen, Taf. XLV.
4 According to Ehrenberg, there are, at the base of each cilium of the rotary organs, many striated muscles, which, acting antagonistically, produce the motion (Abhandl. d. Berl. Akad. 1853, p. 34).
5 But neither Dujardin (Infusoria, loc. cit. p. 579), nor Rymer Jones (Compar. Anat. &c. p. 128), has been able to perceive this apparatus. The contractile parenchyma on which the vibratile discs are situated, appears to be destined only for the protrusion and retraction of the rotary organs.

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* § 133, note 4.] Dobie (Ann. of Nat. Hist. 1847) speaks of two kinds of cilia with *Flocculina*; "one of the usual short vibratile kind, covering the interior of the alimentary tube; the other extremely uniform body found upon most Rotatoria, and in the neck of *Hydatina vento*, and *Notommata coltarts* (Abhandl. d. Berl. Akad. 1839, p. 52, Taf. VIII. 1833, p. 189, Taf. IX., and, Die Infusionsthierchen, p. 386, &c.). Besides this ganglion, he has mentioned with *Hydatina*, *Syncheta*, and *Diglena*, many others scattered through the anterior part of the body, and connecting with the cerebral one by nervous filaments. Likewise, with *Enteropleca*, *Hydatina*, *Notommata*, and *Diglena*, he has regarded as a nervous loop, two the filaments which pass off from the cerebral ganglion, and go to the cervical respiratory orifice. Finally, he refers to the sensitive system, a whiteacular, single or double, and situated behind the cerebral ganglion, with *Notommata*, *Diglena*, and *Theidia* (Die Infusionsthierchen, p. 425). Grant's description of the nervous system of the *Hydatina*, as being composed of many ganglia and a ventral cord, long and filiform, of uniform thickness, and not vibratile under ordinary circumstances. They are slowly moved, being spread out by the contractile substance of the lobes of the rotary organ. — Ed.
§ 135.

Beside the sense of touch, apparently located chiefly in the rotatory organs and their tentaculiform processes, these animals have also an organ of vision. Usually this consists of a single or double eye-speck upon the neck; and sometimes, though rarely, of three or four red specks upon the forehead. These specks are usually very small, but nicely defined, and covered by a kind of cornea. They are situated immediately upon the cerebral ganglion, or are directly connected with it, by nervous filaments.

CHAPTER V.

DIGESTIVE APPARATUS.

§ 136.

The digestive apparatus is well developed with the Rotatoria, and has the following parts:

The mouth opens into a muscular pharynx which has two horny, masticatory organs, which move laterally upon each other. Succeeding this pharynx is a narrow oesophagus of variable length, which leads to a stomachal

(Outlines, &c., p. 88, fig. 32, B.), is founded, undoubtedly, upon supposition, and not upon real observation.¹

¹ The vibratile disc of Conochilus has upon its centre, four cylindrical processes, terminating usually by a bristle, and quite resembling antennae. The two or four styles projecting from the front of Synchaeta, are probably of the same nature.

² The eye-speck is simple with Enclopinus, Notomnata, Synchaeta, Cycloptera, and Brachiodus; double with Conochilus, Megalorchia, Digenia, Rotifer, and Philodina; with Loaphora, there are three, and with Synamella, four; while Hydathia, Entroplea, Piguura, Tuberoloria, and the adult Lioventularia, have none at all.

³ Ehrenberg, who was the first to regard these red dots as eyes, has given their intimate structure in none of his writings; this is the more to be regretted since Dujardin has not regarded them as visual organs (Inseelsc, p. 501). He supports this view by the fact that they disappear with the adult individual; but this objection will appear fanciful when it is remembered that this is also true of certain parasitic Crustacea. At all events, the small ocular dots of Conochilus, Rotifer, and Philodina, are nicely-defined organs surrounded with a solid capsule, and appear to me wholly different from the diffused masses of red pigment which Ehrenberg has erroneously taken for eyes with the Infusoria. The disproportion of size of the red dots which Ehrenberg (Das Infusioristhier-chen, Taf. LI. LIII. LIV.) has figured with Notomnata forcipata, Synchaeta bulbica, Cycloptera, and Loaphora, lead one to suppose that they are only collections of pigmenary granules.

⁴ [§ 134, note 1.] Goeze (Ann. Nat. Hist. 1850, p. 21) describes the nervous system of Asplanchna priodonta as follows: "Each of the three eyes rests on a mass that appears ganglionic; the clubbed masses at the lateral apertures are probably of the same character; and the interior of the body contains a number of very delicate threads, floating freely in the contained fluid, which have thickened knobs here and there, especially where they anastomose."

⁵ Leydig (Zur Anat. und Entwickelungsgeschichte der Lacinularia socialis, in Siebold and Kölliker's Zeitsch. Feb'y, 1852, p. 147) describes a very peculiar nervous system with Lacinularia, consisting of: 1. A ganglion behind the pharynx, composed of four bipolar cells with their processes. 2. A ganglion at the beginning of the caudal prolongation, similarly composed of four larger ganglionic cells and their processes." But, that these parts belong to the nervous system, appears by no means positive; for, as this observer candidly observes, and it is, I think, a capital comment on this whole class of study: "That these cells, with their radiating processes, are ganglionic globules, is a conclusion drawn simply from the histological constitution of the parts, and from the impossibility of making anything else out of them, unless indeed, organs are to be named according to our mere will and pleasure." — Es.
dilatation. This dilatation is continuous into an intestine which opens externally by an anus.

The mouth is always between the rotatory organs, so that it receives what is drawn in by their vertical action,—the animal swallowing or rejecting the particles at will.\(^1\)

The pharyngeal masticatory apparatus is round, and composed of two jaws having one or several teeth, which are brought together laterally by the action of special muscles.\(^2\)

Usually these jaws are formed of two knee-shaped divisions (Processus anterior and posterior). The posterior division gives insertion to the masticatory muscles, but the anterior terminates with a tooth,\(^3\) or as a multidentate apophysis.\(^4\) With some which have this last arrangement,\(^5\) the two jaws are formed of three horny arches, and noted for their stirrup-like form. Two of these arches (Arcus superior and inferior), form the arched portion of the stirrup, pointing inwards, while its base is formed by the third arch (Arcus externus), pointing outwards. The masticatory muscles are inserted upon the inferior arch, and move against each other—the transversely-arranged teeth passing over the other two.

With the multidentate Monotrecha, and Zygotrecha, the pharynx rests always in the same locality; but with the unidentate Polytrecha, it can move up and down, and even be protruded through the mouth. In this last case, the teeth serve as pincers for the seizure of food. The intestine usually traverses the cavity of the body in a straight line, rarely looping,\(^6\) and is lined throughout with ciliated epithelium.

From the stomadal dilatation to a point near the anus, its walls are very thick. The walls of the stomach and intestine are formed of large cells with a colorless nucleus, and which, as they contain a brownish or greenish granular substance, are of an hepatic nature.

With most species, two caeca, rarely more, with thick walls and lined with ciliated epithelium, open on the right and left of the beginning of the stomach. Their walls are also composed of large cells, which, as they differ widely from the hepatic ones by their colorless contents, may perhaps serve the function of salivary glands or pancreas.\(^7\)

The term Rectum has been given to a short and terminal portion of the intestine, which has thin walls, capable of being widely distended by feces. Its orifice is excretory not only of the feces, but also of the contents of the genital organs and of the aquiferous system—and may therefore be regarded as a cloacal as well as an anal opening. It is nearly always at the base of the caudal extremity.

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1. The teardruidiform, rotatory organs of *Stephanocercus*, are also used for the seizure of food; see Ehrenberg, Abhandl. d. Berl. Akad. 1832, Taf. XI. fig. 1, c., also, *Die Infusosthierchen*, Taf. XLIV, fig 11. 5
2. For the structure of the teeth, see Ehrenberg, Abhandl. d. Berl. Akad. 1831, p. 48, Taf. III. IV.
3. *Phaeurotrecha, Farcetaria*, and many species of *Notommata*, and *Digaena*.
4. *Hylatina, Euchamis, Salpina, Anurana, Brachionus*, and many species of *Notommata*, and *Digaena*.
5. *Phildina, Laciactaria, Melicerta*, and *Conochitius*.
6. With *Euchamis*, and *Brachionus*, the stomach is separated from the intestine by a constriction, and with *Phildina*, the intestine is of equal size throughout, except the rectum which is dilated. But it is called, especially with those which are enclosed in a carapace, as with *Tubiculata*, and *Melicerta*, since here the anus is far in front.
7. These two pancreatic caeca are nearly always present, being wanting only with some species of *Idiothyum*. With *Notommata clavulata*, and *Digaena laevigata*, there are, besides these caeca, which are long, attached to the stomach many smaller ones, which are colorless and perhaps of the same nature. With *Megalotrecha albiflava*, there are also two like caecal appendages entering the base of the stomach, and which are independent of the short pancreatic ones of the same locality; see Ehrenberg, Abhandl. d. Berl. Akad. 1831, Taf. III. and, *Die Infusosthierchen*, Taf. L. LIV.
CHAPITERS VI. AND VII.

CIRCULATORY AND RESPIRATORY SYSTEMS.

§ 137.

As no sanguineous system has yet been found with the Rotatoria, it must be admitted that all the organs are bathed directly by the nutritive liquid which transudes through the intestine.¹

§ 138.

The vessels observed with the Rotatoria belong probably to the aquiferous system, which, from its structure and limited distribution, must be regarded as of a respiratory nature. In most species, a straight and riband-like organ is seen upon each side of the body, which contains a stiff, tortuous, vascular form canal. At the anterior extremity of these two lateral bands, their canals connect with many short lateral vessels which open into the cavity of the body,—their orifices being furnished each with a very active, vibratile lobule.²

These lateral orifices have the appearance of pyriform, or oval corpuscles, in the interior of which, the vibratile lobule, produces the aspect, when its motions are diminished by pressure between plates of glass, of a small, flickering flame.

The number of these organs varies with the species, and also, it would appear, even with different individuals of the same species. Usually there

¹ The sanguineous vessels which Ehrenberg has frequently described and figured, have not appeared as such to Dujardin (Infusories, p. 339), Rymer Jones (Comp. Anat. p. 125), De Lee (Ann. d. Sc. Nat. XVII. 1842, p. 201), and myself.

² The so-called annular vessels encircling the body of many species at regular and wide distances, and which, as he himself avows (Die Infusionsthiere, p. 410), are not connected by longitudinal vessels, are undoubtedly only the transverse sulciuations, or muscles. From their extreme tenuity, it is difficult to determine the nature of the other filament organs in the body of the Rotatoria, and which Ehrenberg has also referred to the sanguineous system. But, equally well might they be taken for muscular fasciculi, ligaments or nerves.*

* Ehrenberg was the first to point out these vibratile organs, and designated them as the internal gill-like respiratory organs (Abhandl. d. Berl. Akad. 1833, p. 186).

* [§ 137, note 1] Dalrymple (Phil. Trans. 1849, p. 334) has described with Asplanchna Brightwellii what he regards as a peculiar circulatory system. It consists of a double series of transparent filaments (for there is no proof of their being tubes or vessels), arranged, from above downwards, in curved or semicircular form; symmetrical when viewed in front. These filaments, above and below, are interlaced loop-like; while another fine filament passes in a straight line, like the chord of an arc, uniting the two looped extremities. To this delicate filament are attached tags, or appendices, whose free extremities are directed towards the interior of the animal, and are affected by a tremulous, apparently spiral motion, like the threads of a screw. This is undoubtedly due to cilia arranged round these minute appendages. The tags are from eight to twelve, or even twenty, in number, varying in different specimens." He thinks these organs fulfil their function by the ciliated tags producing currents in the fluid which fills the body of the animal.

These observations are curious and deserve further attention. — Ed.
are two or three on each side, and sometimes there are from five to eight pairs, but rarely more.

The lateral bands approach each other at the posterior extremity, and their canals join in a common, highly-contraction-able vesicle with thin walls, which empties externally its aqueous contents through the cloacal opening.

An orifice, situated usually upon the neck, and sometimes pedunculated, serves probably to introduce the water into the cavity of the body. This water enters the aquiferous system through the lateral vessels which float free in this cavity, and at last is expelled through the contractile vesicle. In this way, a constant renewal of water can occur, and the opening upon the neck may therefore be properly termed a respiratory orifice or tube.

There can be but little doubt that the rotatory organs also, have a respiratory function, for their surface is covered with thin epithelium, and their cilia produce a constant change of the water.

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CHAPTER VIII.

ORGANS OF SECRETION.

§ 139.

Some of the Rotatoria secrete a gelatinous substance, which, hardening, forms the cells and tubes into which they can partly or wholly withdraw themselves. The organ of this secretion is yet unknown; but the secretion appears to be derived from the posterior extremity, and especially from the cloacal opening. 

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2 Notommata copes, and syrinx.
3 With Notommata clavulata, and myrmelco, the number of these organs is remarkable; each lateral band has thirty-six to forty-eight; see Ehrenberg, Die Infusionsthierechen, Taf. XIX. I.
4 Ehrenberg was the first to direct the attention of naturalists to these two lateral bands and their contractile vesicles; but he regarded them as two testicles with their vesicular seminales (Abhandl. d. Berl. Akad. 1830, p. 51). The incorreceness of this opinion, and which he has maintained in his grand work, cannot be doubted, if it is considered that these two bands with their appendages are already developed and in activity with the young animals, and this even before they have escaped the cavity of the parental body.

In all Ehrenberg's published figures, one notices nothing of the flexuous canals of these organs, and which, therefore, he does not appear to have observed.

5 The respiratory orifice is cervical with Enteroplia, Hydatina, Diglena, and many species of Notommata; but, with Rotifer, Philodina, Brachionus, and some species of Salpina, Euchlanis, and Notommata, it is replaced by a tube. With Actinurus, exceptionally, a simple respiratory tube is placed under the throat; and with Tubicolaria, and Melicerta, there are two in the same region.

1 With Conochilus, and Lecanaria, where several individuals are attached by their tails around a common centre, the nucleus of one of these colonies is formed by a few, gelatinous substances, in the cells of which these animals can partially withdraw themselves. With Oecisten, Tubicolaria, Stephanoceros, Floscuclaria, and Limnaea, each individual occupies an isolated and more or less hard gelatinous tube (Ehrenberg, Die Infusionsthierechen). The tubes of Melicerta, of which Schaffer has given an excellent figure (Die Blumen-polypen derissen Wasser 1756, Taf. I. II), are very remarkable, and according to Ehrenberg, are composed of brown polygonal cells which are exerted through the cloacal opening and glued together (Die Infusionsthierechen, p. 496).
§ 140.

THE ROTATORIA

CHAPTER IX.

ORGANS OF GENERATION.

§ 140.

Although it is certain that the Rotatoria propagate only by genital organs, yet the female organs only are yet well known. These consist of a single or double ovarian tube of variable length, situated upon the sides of the intestinal canal at the posterior part of the cavity of the body, and opening into the cloacal cavity through a short oviduct. These ovaries never develop but a few eggs at a time. The mature eggs are always oval and surrounded by a simple, solid, colorless envelope. They contain a finely granular and usually colorless vitellus, in which there is a distinct germinative vesicle. Many species are ovigers, but a few only are viviparous.

It would be naturally supposed that these animals, which have such distinct female organs, would have also those of the other sex. But as yet the most minute researches have failed to detect them. It is therefore doubtful whether these animals are hermaphrodites or of separate sexes.

1 For the various forms of the ovaries see the classical works of Ehrenberg. With Philodina rosea, Brachionus rubens, and Mustigoeveca carinata, the vitellus of the eggs as well as the parenchyma of the body is of a reddish color. With those species which live in the tubes, the eggs are usually deposited in the cavity of these last. But with Triarthra, Polychaeta, and Brachionus, they remain glued to the cloacal opening.

With Philodina, the young are often hatched in the cavity of the parent body, and are, according to Ehrenberg (Die Infusionsthierchen p. 455), always surrounded with an extensible membrane of the ovary (uterus). But it has always appeared to me that the mature eggs of the viviparous Philodinae, are detached from the ovaries and fall into the cavity of the body, where afterwards the hatched young move about. Perhaps oviducts are here wanting and the young escape from their parent through an orifice near the cloacal opening.  

2 Admitting that there are here male genital organs, the respiratory tube upon the neck of the animal, he observed a well-defined intro ductive organ connected with the testis, and a passage for its extension from the body of the animal. In verification of this observation it may be mentioned that Brightwell observed the actual cauda between the sexes, and Gosse (loc. cit. p. 23) has witnessed the development of the males from the eggs.

Huxley, on the other hand (Quart. Jour. Mic. Sc. No. 1. Oct. 1852, p. 1), has found with Lacinulata no trace of a male individual, but in some specimens he observed singular bodies which answered precisely to Kükenthal's description of the spermatogenic particles of Megalostrocha. He says, 'They had a pyriform head about 1-1000 in. in diameter by which they were attached to the particles of the body, and an appendage four times as long which underwent the most extraordinary contortions, resembling however a vibrating membrane

13§
Their embryonic development occurs, as in most invertebrate animals, through a complete segmentation of the vitellus; and the embryonic cells then appear in the segmented portions.

The newly-hatched embryo has already rotatory and masticatory organs, eyes, feelers, &c., and the general form of the adult animal. 1

Many species was formerly taken for a penis. But the correctness of this view has since been seen, for no ease has here observed the copulatory act. According to Ehrenberg, who regards these animals as hermaphrodites, certain parts of the aquatic system represent the male organs. He regards the two lateral bands as testicles, and their interior extremes as vasa deferentia, while the contractile vesicle is the vesicula seminalis. But as at these parts an homogeneous aqueous fluid, in which there is at no time anything like spermatides, moreover these are fully developed in the young individuals which then have no trace of female organs.

It would be wholly anomalous that these animals should constantly secrete sperm during their whole life. One would therefore wholly asseme to the doubts of Dejardin (Infusoria, p. 577), upon this view of Ehrenberg, and some contradictions into which this has fallen upon this subject, have been noticed by Doyère (Ann. d. Sc. Nat. XVII. 1842, p. 199). Kulikker has also thought this view unfounded, and has sought to remove the doubts by a search after the spermatidal particles. He regards as such, with Megalotrocha alboflavicans, the peculiar tumbling bodies which he has seen in the cavity of the body, since they are composed of a typical body, to which is attached a movable tail. These bodies he affirms are developed in round cells, often unciliated, and he has often counted ten to twenty in the same individual. As he also asserts to have seen eggs at this time in the same individual, this would certainly be a proof of the hermaphroditism of these animals (Froenic's neue Not. No. 28, 1843, p. 17). But this whole observation is somewhat suspicions, for Kulikker has very probably confounded the vibratile lobules of the aquatic system with the spermatides, and of which there are four with Megalotrocha in the anterior extremity.

The observation of R. Wagner (Ibis, 1832, p. 388, Taf. IV, fig. 1, 7) is particularly worthy of attention, for followed out, it might lead to the discovery here of male genital organs. He has described peculiar eggs, found frequently by him with Hydrodina senta, and whose whole surface is covered with very fine, thickly-set hairs. He has regarded these as in their first stages of development, although Ehrenberg (Abhandl. d. Berl. Akad. 1835, p. 154, and, Die Infusiosfierchen p. 410), has taken this vilius envelope for an alga of the genus Hydrocoela. But these vilius envelopes have always reminded me of the masses of spermatic particles in the testicles of fishes and which have been figured by Heine as whitish felt-like globules (Muller's Arch. 1835, p. 554, Taf. XIV. fig. 6. a.).

[Additional Note.] Kulikker (Neue Schweiz. Denkschr. VIII. Taf. II. fig. 31, a.) having since figured the spermatidal particles of Megalotrocha alboflavicanus, my former view that he had confounded these with vibratile organs, is incorrect. 1

1 Kulikker was the first to observe the complete segmentation of the eggs, with Megalotrocha (Froenic's neue Not. Loc. cit.). It wholly escaped the observation of Ehrenberg and his numerous researches upon the eggs of these animals; see Abhandl. d. Berl. Akad. 1835, p. 162; 4

more than the tail of a spermatozoon." He very judiciously concludes that they cannot at present be definitely regarded as spermatic particles. — Eb.

* [§ 140, note 2.] The subject of the form and character of the spermatic particles of the Rotatoria is quite interesting, as it may perhaps throw some light on the position of these animals in the animal kingdom. As yet, however, we have very few observations, and even these are not fully definite.

Schmidt (Vergleiche. Anat. &c. p. 288, note) speaks of the spermatic particles of Euchilaniis monorara, as being cercaria-form.

Leydig (Siebold and Kulikker's Zeitsch. III. 1838, p. 471) speaks of the spermatia of Loculinalia as composed of a nuclear body from which radiate many tails, like these particles with the Decapods.

See Taf. XVII. fig. 2. — Eb.

[End of § 141.] We are indebted to Leydig (Zur Anat. u. Entwickelungsgesch. d. Loculinalia socialis, in Siebold and Kulikker's Zeitsch. III. p. 452) and to Huxley (loc. cit. p. 11-15), for extending our knowledge in this direction. They have carefully observed the development of Loculinalia, and the phases correspond exactly with those of Megalotrocha as described by Kulikker.

But beside this ordinary mode of reproduction, they have observed another which is a sexual and analogous if not identical with what has been observed with some of the lower Crustacea (see infra § 292), — propagation by the so-called hibernating eggs. Their observations throw light on the whole of this interesting subject, and have fully confirmed me in my previous conjectures that these "ova" are only genuine having their exact representative in the shell-like eggs of the viviparous Aphides. — Eb.

† [§ 141, note 1.] Kulikker's observation above-mentioned on Megalotrocha, has since been confirmed by Leydig (Ibis, 1843, p. 170) who has observed it likewise with Notommata and Euchilaniis. — Eb.
BOOK EIGHTH.

ANNELIDES.

CLASSIFICATION.

§ 142.

The Annelides are distinguished from all other worms by their ventral, ganglionic cord, and by their annulated body, at the two extremities of which there is a mouth and anus. They resemble the Arthropoda, but at the same time differ from them in having a completely closed vascular system, and in wanting articulated, locomotive organs. The epithelium of their body is not ciliated except where it covers the external branchiae.

The Nemertini, which have hitherto been classed among the Turbellaria, belong more properly to the Annelides, since their body is more or less distinctly articulated, and its parenchyma closely resembles that of the Hirudinei. Moreover, the power which many of them have to divide spontaneously into many segments, is another affinity with various Annelides. It will therefore appear proper to unite the Nemertini with the other Annelides in the following manner:

ORDER I. APODES.

Body without bristles.

SUB-ORDER I. NEMERTINI.

Posterior extremity of body without a sucker; cephalic extremity often provided with lateral respiratory fossae.

1 Since Kühn (Verhand. d. Schweiz. naturf. Gesclisch. zu Chur. 1844, p. 89) and Quattrocchi (Ann. d. Sc. Nat. VI. 1846, p. 173) have published their researches on the anatomy of the Nemertini, I have, also, during my last visit at Trieste in 1847, been convinced that these animals should be classed among the Turbellaria, and that they especially deserve this name since their entire body is covered with very distinct vibratile cilia. — Additional note.
Genera: Tetraestemma, Polystemma, Micrura, Notospermus, Meckelia, Polia, Nemerter, Borlasia.

SUB-ORDER II. HIRUDINEI.
Posterior extremity of body provided with a sucker.


ORDER II. CHAETOPODES.
Body provided with bristles.

SUB-ORDER III. LUMBRICINI (ABRANCHIATI)
Body without feet.


SUB-ORDER IV. CAPITIBRANCHIATI.
Body provided with feet; branchiae situated upon the cephalic extremity.


SUB-ORDER V. DORSIBRANCHIATI.
Body provided with feet; branchiae situated upon its segments.


BIBLIOGRAPHY.

§ 142. THE ANNELIDES.


ADDITIONAL BIBLIOGRAPHY.

Besides the references in my notes, see the following writings:


—— Anatomisches über Branchellion und Pontobdella. Ibid. III. 1851, p. 315.

CHAPTER I.

CUTANEOUS SYSTEM.

§ 143.

The skin of the Annelides consists of a very thin, non-ciliated epidermis, and a more or less compact dermis composed of solid, but delicate fibres obliquely intertwisted.

The iridescence and often splendid colors of many of the Chaetopodes, are not due to a pigment, but to an optical effect produced by the reticulated union of the dermic fibres.

But the Apodes, on the other hand, owe their many colors to a pigment net-work and cells. Usually the epidermis is separated with difficulty from the dermis, but with many Capitibranchiati, and Dorsibranchiati, the opposite is true. With the Apodes, the skin is closely united with the subjacent muscular layer.

With many Dorsibranchiati, the skin has filiform or lamellar appendages sometimes so much developed that they overlap each other like scales. With some Chaetopodes, there are, beside the bundles of locomotive bristles and hairs, numerous appendages of this kind covering most of the body.

CHAPTER II.

MUSCULAR SYSTEM AND LOCOMOTIVE ORGANS.

§ 144.

The muscles of the Annelides, although highly developed, are never striated.

The whole body is enveloped by a subentaneous muscular layer divisible into three sheets: an external, of circular fibres; an internal, of longitudinal fibres; these are the most developed. Then a middle one composed of obliquely intertwisted fibres; this is less distinct, and sometimes entirely wanting.

1 The external respiratory organs alone are covered with ciliated epithelium. Orsted (Beechreira, d. Chaswarmer, loc. cit. p. 77) however, affirms that the body of the Nemertini is provided with vibratile cilia. But this is to me improbable at least with the large species of Boweria, Nemertes, and Polia.

At all events this statement of his requires new proof. See additional note under § 142.

Scaly appendages of this kind cover the back of Abygadite, Polynoe, and Sigealton. With Polynoe squamata, they are very easily detached.

2 The back of Aphrodite hystrix has numerous bristles and hairs; with Aphrodite aculeata, these hairs are so thickly set that they conceal the back by a kind of felt.

The middle muscular sheet is found with the Hirudinei and Lumineriditi; see Brandt and Ratzeburg, Med. Zool. II, p. 214, Taf. XXIX. fig. 1, 2; and Morren, loc. cit. p. 83.

But with the Nemertini it is wanting; see Rathke, Neueste Schrifft. d. naturf. Gesellschaft, in Danzig, loc. cit. p. 55.
§ 145. THE ANNELIDES.

With the Apodides, this muscular envelope so closely embraces the visera, that the cavity of the body is made very small. But with the Chaetopodes, this cavity is larger.

With many of the Branchiati, the muscular fibres form distinct fasciculi — so that instead of a common muscular envelope there are longitudinal and annular muscles distinct from each other. (2)

With many Chaetopodes, the internal surface of this envelope sends off annular muscular septa into the cavity of the body, at the junction of the segments, — thus dividing this last into as many chambers as there are segments; sometimes these septa bind the intestinal canal so closely, as to regularly constrict it. (3)

§ 145.

Besides the common subcutaneous muscles, which produce the vermicular motions of the body, there are other groups: 1st. For the auxiliary locomotive organs, and 2nd, for many other organs.

1. The Hirudinei are distinguished, as is well known, by a sucker situated at their posterior extremity, which contains both circular and radiating muscular fibres. This sucker serves both to move and to attach the body.

All the Chaetopodes have short, horny stings (aciculi), and long bristles (setae), united in fasciculi of various forms, which they use as fulera when they creep, or as oars when they swim.

With the Branchiati, these organs are most fully developed, and are nearly always situated laterally upon a double row of fleshy knobs; and those of the two inferior rows may be regarded as rudimentary feet.

The Lumbricini have short and usually S-shaped stings which are arranged in many rows upon the belly, and may be wholly withdrawn into the abdominal cavity.

Beside these last, Nais has also a row of bristles each side of the body. (1)

The number of these organs may therefore vary very much upon the different segments of the same individual. It is remarkable that with the Lumbricini the stings are often detached interiorly, and falling into the cavity of the body form there tough masses which are glued together by a viscous substance lodged in the posterior chambers of the body; see Hofmeister, De vernulis quibusdam loc. cit. Tab. II. fig. 3, and in Wiesmann’s Arch. 1844, I. p. 296. These agglutinated masses in which are lodged usually various kinds of visceral parasites, have been taken by Montagne (Observ. sur les Lumbrics, in the Mem. du Museum I. p. 246, fig. 5, 6, 7) for the eggs and foetuses of the Lumbricini. Morren (loc. cit. p. 106, Tab. XXV.—XXIX.) has gone even further, by taking these stings for the chrysalids, and their enclosed vibrators for the embryos of these animals.

2 These separate muscles are found in Apodides, Polygloes, and Nercis, with which the longitudinal ones especially, are seen separated into dorsal, ventral and lateral layers. See for the subcutaneous muscles of the Branchiati in general, Rathke, De Boggyo et Nereide, p. 29, Tab. XI., and in the Darmag. Schrift. loc. cit. p. 62, Tab. IV. fig. 5; also Oppel, Zur Anatom. Physiol. d. Kichems Amirn, p. 4. et seq.

3 When these septa are largely developed, and embrace closely the digestive canal, as in Lumbricini, Sabella, Serpula, and Eunicite, there are always foramin in these disquiagrus or septa, through which the contents of the cavity of the body can pass from one chamber into another.

1 The stings and bristles of the Abranchiati, upon whose various forms see Ortedi (Conspicuation generum specierumque Naidum, in Kroger’s Naturhistor. Tidskrift. IV. 1842, p. 128, Pl. III.), are easily lost from use, but are as easily reproduced.

2 {§ 144, note 3.} The development and intimate structure of the muscles of the Annelides has been carefully studied by Leydig (Stebold and Külliker’s Ztsch. 1. 1849, p. 103) upon Pisicola, Cleptina, Nephtien, and other Hirudinei. The muscular fibre is here developed as in the higher animals out of large nucleated cells arranged in rows, and the adult fibre often shows the relics of these elementary parts. The fibre is not transversely striated, and is composed of a structureless envelope or sheath which is filled with a fine granular substance; see loc. cit. Taf. VIII. fig. 13-23.

See also Haist, De struct. Muscul. in genere et annulat. musculis in specie, Diss. Dorpat, 1846. — En.
With the Branchiati, these organs are often of a cultrate, lanceolate, or sagittate form. Often too, they are denticulated, or barbed upon one or both of their sides, and sometimes they appear articulated.\(^2\) These stings and bristles are moved by a special, muscular apparatus, consisting of many short muscles which arise from the internal surface of the cavity of the body and pass obliquely front and behind to the bases of these organs. These bases project into the cavity of the body, and as their fasciculi are surrounded by a common membranous sheath, when all the muscles contract at once, these organs are thrust out; but they move in various ways, when the muscles contract separately. The other transverse muscles which pass either from the median line of the belly, or from the anterior and posterior parts of the body, and are inserted at the base of these organs, retract them anew into the cavity of the body.\(^3\)

2. With many Branchiati, there is a group of longitudinal muscles at the cephalic extremity, which, arising from the internal wall of the anterior segments, act as elevators and depressors of the oesophagus,\(^4\) as well as retractors and protractors of the fasciculi of the cephalic bristles and tentacles.\(^5\)

\[\text{CHAPTER III.}\]

\[\text{NERVOUS SYSTEM.}\]

\[\text{§ 146.}\]

The nervous system is highly developed in all the Annelides excepting the Nemertini.

The central is distinctly separated from the peripheral portion. The first is usually composed of a row of ganglia, joined together by nervous cords upon the median line of the body.

The most anterior ganglion, and which in some respects may be considered analogous to the brain of the higher animals, rests upon the oesophagus, although the rest of the ganglionic chain which is situated on the median line under the digestive canal, may be regarded as a ventral cord. This cerebral ganglion differs from the others in its larger volume, and appears to be the product of a fusion of two or more symmetrically-arranged unequal-sized ganglia. These ventral ganglia are of uniform size, although not always of the same number with the segments of the body. Strictly, each of them is composed of two ganglia blended together either very perfectly, or very incompletely. The cerebral ganglion is joined to the first of the ventral chain by two cords which surround the oesophagus

\[\text{2 For the nearly inexhaustible variety of form of these horny locomotive organs, which, when cultrate, or lanceolate, are used as weapons of defense, see Andauton and Milne Edwards, Classification des Annelides, loc. cit. XXVII, p. 370, and Gravé, Gründlade Annulata und Annullatorum Basiliarum Conspectus, fasc. I. Pl. I.}\]


\[\text{4 Aphrodite, Nereis, and Arenicola.}\]

\[\text{5 Amphitrite, and Siphonostomia.}\]
laterally, thus forming a ring (the oesophageal ring) through which the oesophagus passes.

§ 147.

The histological elements of the nervous system of these animals, are arranged in the following manner: 1

The central mass of the nervous system is enveloped by a fibrous tissue (Neurilemma), of longitudinal and transverse fibres which are often covered with special pigment cells.

The nervous cords and filaments are composed of extremely fine, primitive fibres, between which in the ganglia are situated various-sized cell-like ganglionic globules. 2 Some of these primitive fibres pass from the cerebral ganglion through all the ventral ganglia, while others pass off from the central ganglia to the peripheric nerves. Many of the ganglionic globules of the brain and abdominal cord are remarkable for their longer or shorter prolongations which may be traced even into the roots of the nerves. 3

§ 148.

The nerves are given off usually from the ganglia, and rarely from the interganglionic cord. The cerebral ganglion sends off nerves to the organs of sense in the head, and to the labial, proboscideal, and masticatory organs about the mouth. Its development therefore corresponds exactly to the more or less complicated condition of the cephalic extremity.

The ventral ganglia send off from each side usually two or three symmetrically-arranged main nerves to the muscles and skin.

It is with the Annelides that there have been found the first traces of a vegetative or splanchic nerve (Nervus splanchicus). This consists of delicate filaments which are distributed upon the intestinal canal, with here and there enlargements, and which anastomose, some directly with the oesophageal

1 Our knowledge of the intimate structure of the nervous system of the Annelids is as yet based upon researches of that of the Hirudinei only: see Helmholtz, De fabrica systematis nervorum, et laborum disertatis, Berol. 1842, p. 12; Hanover, Recherches microscopiques sur le système nerveux, Copenhagen, 1844, p. 73; Will, Verlaut, Mittheilung über die Struktur der Ganglien und den Umfang der Nerven bei wirbellosen Thieren, in Mutter's Arch. 1844, p. 82; Ehrenberg, Beobachtung einer auffällenden bisher unerkannnten Struktur des Seedenorgans bei Menschen und Thieren, in the Abhandl. d. Berl. Akad. 1834, p. 720, Tab. VI. fig. 7; and Valentin, Über den Verlauf und die letzten Enden der Nerven, in the Nov. Act. Acad. XVIII. 1836, p. 202, Tab. VIII.

2 Valentin declares that he has seen in the brain

3 [§ 147, note 3.] This alleged relation of the elements of the nervous tissue is a point of no little histological importance and I shall give it a special consideration in noticing the minute structure of this tissue with the higher animals. I have made no observations on the animals in question, but and ventral ganglia of the leech so regular and symmetrical an arrangement of the ganglionic globules, that those of the two lateral halves corresponded exactly as to number, volume and position; see Valentin, loc. cit. p. 298, Tab. VIII. fig. 62, &c. This symmetry must appear highly astonishing.

4 These prolongations give the ganglionic globules a clavate aspect, as already seen and figured by Ehrenberg (loc. cit. Tab. VI. fig. 7, and fig. 7.11, 7.12.)

Further researches must decide if these prolongations are really continuous with the primitive nervous fibres, as Helmholtz (loc. cit. p. 15), and Hanover (loc. cit. p. 73, Tab. VI. fig. 78), affirm to be the case; for, Valentin in his apparently so careful researches, has never seen any trace of a clavated or pedunculated ganglionic globule.”

Leydig, an excellent observer, confirms the general view here advanced of the direct connection of the ganglionic globule with the nerve-tube; see loc. cit. p. 130, Taf. X. fig. 67 (Pisicola). See also Bruch, Siebold and Kötiker’s Zeitsch. 1849, p. 175, Taf. XII. fig. 7, 8, 9.—Ed.
ring, and others with the cerebral ganglion by means of other small ganglia near the cephalic extremity.\(^1\)

With the different orders and sub-orders of the Annelides, the nervous system has the following modifications:

1. The Nemertini differ remarkably from the other Annelides in this respect; for their ventral cord is without ganglionic enlargements, and composed of two separated cords, one on each side of the body, which send off, right and left, lateral branches along their course. These two cords arise at the anterior extremity in two ganglia blended together above the oesophagus, which represent the cerebral ganglion, and send off many nervous branches in front.\(^2\)

2. With the Hirudinei, the ventral ganglia are much fewer than the segments of the body, and are bound together by two contiguous cords. The first and last of these ganglia are remarkable for their size. The first sends filaments to the lips, the second to the caudal sucker.\(^3\)

The Splanchnic system is composed of a small ganglion situated in front of the cerebral one, and with which it is connected by two filaments. By its side are two others, which are also small and connect with the cerebral by delicate threads. All three send branches to the oral parts, while a delicate filament goes to the inferior surface of the intestinal canal, and represents an inner splanchnic nerve.\(^4\)

3. The ventral medulla of the Lumbricini consists of two nervous cords

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1 Brandt, Bemerkungen über die Mundmagen-oder Eingeweide-nerven der Eierzehren. Leipzig 1836, p. 22.
2 Rathké (Danzig, Schrift. loc. cit. p. 106, Taf. VI, fig. 10, 11) has thus described the nervous system of Borlasia atrita. He has seen particularly two pairs of cephalic nerves arise from the cerebral ganglion. One and the larger of these is principally distributed to the respiratory fossae of the head, while the other, the smaller, passes directly in front, probably for the verniform organ upon the cephalic extremity. Orsted (Beschreib. d. Pluteusmusse loc. cit. p. 5, 15), appears to be wrong in suspecting that Rathké has taken the vascular for the nervous system, for Quatrefages (loc. cit. p. 15, Mon. de Civier, Zoophytes, Pl. XXXIV, fig. 1) has figured by the side of the vascular system, the nervous system of Nemertes Camallux, exactly as it is described by Rathké.

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\(^3\) See Brandt and Ratzeburg, Med. Jod. II, p. 239, Tab. XXIX, B. (Sanguisuga medicina). and Leo, in Müller's Arch. 1855, p. 422, Taf. XI, fig. 10 (Piscicera geotripes). Wagner has found an arrangement quite different from the above, in Pontobdella maricata (Ibid. 1854, p. 191, Taf. I, fig. 3). He saw here the ventral ganglion united by a single cord which sends off from each side only a single nerve. This nerve, after a short course, has a ganglion, and then divides into lateral branches. According to Stannius, these lateral branches are not united together by longitudinal cords as is the case with the Amphipods.

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which are nearly blended together into one, and whose closely-successive ganglia correspond numerically with the segments of the body. (5)

4. With those Chaetopodes which have external branchiae, the nervous system is most highly developed, but has wide variations as to its whole or its details, according to the more or less complicated structure of the cephalic extremity and segments of the body. With those species which are without antennae and eyes, the ventral medulla is composed of two contiguous cords the enlargements of which are indistinct and not sharply defined. (6)

These two cords are separated at the cephalic extremity, and terminate either, by a ganglion on each side without apparently forming by a commissure an esophageal ring, (7) or by encompassing the esophagus, and forming a ring through a ganglion lying upon it. (8)

With some, the two parallel cords are without ganglia but are reunited at each segment of the body by two transverse threads. (9) With others, this connection occurs through transverse threads and ganglia. (9) There are many Branchiata with which the two cords are so closely contiguous that they are separated only by a longitudinal furrow. Their round or elongated ganglia are then common, and succeed each other at longer or shorter intervals. (10) With an entire series of the Diosirbranchiata, the ventral ganglia are so closely approximated that the interganglionic cords appear wholly wanting. (12)

The brain is composed of only two ganglia, which are more or less blended into one with the Capitibranchiata, and with those Diosirbranchiata whose head is very slightly developed; (23) while with the other Diosirbranchiata whose head is distinct and the eyes and tentacles very much developed, it is the product of the fusion of many ganglia. (14)

5 See Grauthuisen, in the Nov. Act. Acad. XIV. 1825, p. 412, Tab. XXV, fig. 3-5 (Chao-

6 taster diaphanus); Hente, in Muller's Arch. 1857, p. 84, Taf. VI. fig. 2, 3, 8, x, y (Eneki-

7 tramus); Roth, de Animalium invertebrarum systematis nervis: Wirzburg, 1825, fig. 3; and Morren, loc. cit. p. 117, Tab. XIX.—XXIII.

8 (Lumbricida terrestrialis) In the common Lumbricidaes, two pairs of nerves (Nereti annulareis) pass off laterally from the centre of the ganglionic enlargements; and between every two ganglia, exceptionally, there passes off another pair (Nereti interannulareis) which are distributed to the transverse muscular septa; see Morren loc. cit. The nervous system of Stenurus thalassomonoides is quite different, and appears retrograded to the type of that of the Saponellidae, for the ventral medulla consists only of a simple cord which is enlarged at the caudal extremity; see Will, in Muller's Arch. 1842, p. 427.

9 Arenicola, Ammodytus, and Terebellia. 7 Arenicola; see Grube, Zur. Anat. d. KIemen-

10 wurmer, p. 17, Tab. I. fig. 7; and Stannius, in Muller's Arch. 1840, p. 573, Tab. XII. fig. 15.


12 Sabella; see Wagner, Isis, 1832, p. 567, Taf. X. fig. 14.; and Grube, Zur. Anat. d. KIemen-

13 wurmer, p. 30, Taf. H. fig. 16.

14 Phylaclode. Here, the transverse threads commence only at the border of the 7th or 8th gan-

15 glia. They alternate regularly with these and
disappear towards the last segments of the body; see Quatrejases, Ann. d. Sc. Nat. 11. 1844, p. 55, Pl. II. fig. 2, 3.

16 Siphonostomatum, Amphitrite, Amphinome,

17 Ariochela, Polynoe, and Aphrodite. With Si-

phonostomatum, the ventral ganglia are very long; see Rathke, Dunzlig, Schrift. loc. cit. p. 98, Taf. VI. fig. 3. Here, the peripheral nerves are given off from the interganglionic cords and not from the ganglia themselves.

With Amphitrite, the ventral ganglia are long also, but from the fifth segment of the body they alternate with others that are round, so that each segment has two ganglia. Both of these ganglia furnish exclusively the peripheral nerves, but in front where the round ganglia are wanting, they are furnished also by the interganglionic cords; see Rathke, loc. cit. p. 78, Taf. V. fig. 7, 15. With Ariochela (Quatrofages, loc. cit. p. 96, Pl. II. fig. 5), and Amphinome (Terebranum, Beobacht. aus d. Zoot. u. Physiol. 1832, p. 83, Taf. XI. fig. 72), the ganglia are very closely set together. With Aphrodite, and Polynoe, the number of ventral ganglia exceeds that of the segments of the body; see Grube, loc. cit. p. 66.

12 Nerei, Eunice, Glyceria; see Wagner, in Isis, 1834, p. 155, Taf. 1. fig. 11; Muller, in the Ann. d. Sc. Nat. XXII. 1834, p. 22, Pl. II. fig. 10; Rathke, De Bopyro et Nereide p. 41, Tab. II. fig. 15; Grube, Zur. Anat. d. KIemenwurmer, p. 43, Taf. II. fig. 9; and Quatrejases, Ann. d. Sc. Nat. loc. cit. Pl. I. fig. 1, 2, 3.

13 Amphitrite, Siphonostomatum (Rathke, Dunzlig, Schrift. loc. cit. Taf. V. fig. 7, 14, Taf. VI. fig. 3), and Glyceria (Quatrofages, Ann. d. Sc. Nat. loc. cit. p. 98, Pl. II. fig. 5).—

14 Nereis, Ctenocap, and Phylaclode; see Mul-

15 ler, Ann. d. Sc. Nat. loc. cit. Pl. IV. fig. 19; Rathke, De Bopyro et Nereide, p. 43, Tab. II. figs. 4, 5, 13; and Quatrofages, loc. cit. p. 51, Pl. I. fig. 1, 2, Pl. II. fig. 1.


16 1849, p. 500 (Chlororina). — Eu.
With the Dorisbranchiati, the many delicate threads which arise from the cerebral ganglion by special roots and pass to the different portions of the digestive canal with a ganglion here and there upon their course, may be regarded as splanchnic nerves.\(^{(15)}\)

With the Amphinomae, Eunicceae, Nereideae and Arieceae, there arise from the posterior border of the cerebral ganglion two roots which may be regarded as Nerei pharyngei superiores, and which unite near their origin into a Ganglion pharyngeum superior. From this last pass off posteriorly delicate threads which form many ganglia upon the esophagus, and afterwards spread over probably many other parts of the digestive canal.

Beside this Plexus splanchnicus superior, there is sometimes a Plexus splanchnicus inferior — formed by other roots which pass off inferiorly from the brain; part of these form under the esophagus a Ganglion pharyngeum inferius, while others, passing backwards, constitute Nerei pharyngei and esophagei.\(^{(16)}\)

The Amphinomae have on each side of the abdomen a very remarkable ganglionic chain. Their ganglia intercommunicate, not only by longitudinal, but also by transverse anastomoses, with the central mass of the nervous system. Among these last, those which are given off from the anterior lateral ganglia, join the connecting filaments of the esophageal ring; while the others, arising from the posterior lateral ganglia, go to the various ganglionic enlargements of the ventral cord.\(^{(17)}\)

It has not yet been possible to ascertain the signification of these lateral ganglionic chains.

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\(^{(15)}\) Cuvier (Loc. d'Anat. Comp. II. 337) has noticed with Aphrodite two nerves passing back wards which ought to be regarded as of a splanchnic nature; but Grube (Jahr. Anat. d. Kiewen-würmer, p. 58) has been unable to find them even in the same species.

\(^{(16)}\) Stannius (Jahr. 1831, p. 953, Taf. VI. fig. 8, r. r.), and Grube (De Plécone caraculata, 1837, p. 9, fig. 5, r.), have seen with certain species of Amphi nomae the two roots of the Plexus splanchnicus superior, but were unable to trace them further. However, with Eunicce Nereus, Grube (Jahr. Anat. d. Kiewen-würmer, p. 45, Taf. II. fig. 9, l.) has found beside these two roots, the Ganglion pharyngeum superior which they form, and the nervous filaments which pass off from this last. Quite lately, Quaretage has given very exact and detailed descriptions and figures of the expansions of the Plexus splanchnicus superior and inferior, with Eunicce Nereus, Oligera, Phyllodoces, and Arie tina; see Ann. d. Se. Nat. 1844, II. p. 31, Pl. I. II.

\(^{(16)}\) These two ganglionic chains were first described by Stannius with Amphinome rostrata (Linn. 1831, p. 980, Taf. VI. fig. 4). He saw three ganglia connect with the esophageal ring on each side. But Grube (De Plécone caraculata, p. 19, fig. 5) has seen six on each side with Amphinome caraculata. These lateral ganglia, moreover, remind one of those described by Wagner, as already noticed with Pontobetella muricata.

1 According to Raths (Danish, Schriff. loc. cit. p. 91, 100), the two cephalic and respiratory fossae with the Nereidum, are the seat of a most delicate sense of touch; and their white, long and protrac tile probosces is also a tactile organ. But other naturalists attribute wholly different functions to these organs.

2 The proboscis is not-articulated with Nats pro bosicides, and Eunices hilformis (Grube, Wieg meister's Arch. 1844, I. p. 204, Taf. VII. fig. D), but it is articulated with Rhynchelema (Hoff meister, Ibid. 1843, I. p. 192, Taf. IX. fig. 8).
often very prominent tactile organs, in the form of processes of variable number and shape, which are situated principally though not entirely upon the cephalic extremity of the body. Those upon the head have been named Antennae, and the others Cirri. These last are often very numerous upon the first segment of the body. Both are contractile and usually unarticulated, though sometimes having very distinct joints. The antennae receive their nerves directly from the cerebral ganglion, while those of the cirri of the first segment, are given off from the base of the two lateral cords of the cesophageal ring, and from the first ventral ganglion.

II. Organs of Vision.

§ 150.

With nearly all the Capitibranchiati, and with many Nemertini, and Lumbricini, the eyes are wanting. But, as visual organs, have been regarded the brown or black dots, which are two in number with many Nais, four with Tetrastemma, but are innumerable and arranged irregularly or in rows upon the neck, with Polyctenem and Nemertes. But these are scarcely more than simple pigment dots.

With the two to ten eye-specks of the Hirudinei, however, the structure is quite different. Here the eye is composed of a transparent cylindrical body, a little attenuated and rounded at its inferior extremity, while the opposite one causes the skin to bulge out like a cornea. Its remaining portion is

3 The antennae of the Annelides have been distinguished from those of insects by being termed Tentacula; for they are non-articulated, while those of insects are articulated. But this distinction is not valid, for, with the Branchiata, there are insensible transitions from the non-articulated tentaculsa to the articulated antennae. But another and more essential difference is, that those of the Annelides are contractile, while those of insects are not. These organs are articulated with Eseice, Peripatus, and Stylist. In this last it is true of the cirri also. The modifications and varieties of the antennae and cirri belong, however, to the province of Zoology.

4 With Nereis, four nerves pass off from the anterior portion of the brain to the four antennae; the two external as gustatory nerves and which go to the larger antennae, are largely swollen at their extremity; see Rathke, De Bopyro et Nerede, p. 43, Tab. II. fig. 4, 5.

5 See Rathke, ibid. Tab. II. fig. 18, d. d. and in the Danzig. Schriften loc. cit. p. 76, Tab. V. fig. 14, d. d.

6 A remarkable exception to this occurs with Amphitritea Sabella as described by Ehrenberg (Mitchell aus d. Verbandli. d. Gesell. natur. Freunde zu Berlin, 1836, p. 2). It has, it would appear, two eyes not only at the cephalic extremity, but at the opposite one also.

7 Grubthiius (Nov. Act. Acad. Nat. Cur. XI. p. 242) has described the two eyes of Nais proboscidea as particles of pigment enveloped by a sensitive parenchyma. But this is not based upon observation, and is an hypothesis only, as Muller has very judiciously remarked (Ann. d. Sc. Nat. XXII. 1831, p. 20). The assertion of Quatrefages is of more weight (Comp. rend. XIX. 1844, p. 190). He affirms that the pigment specks of many Nemertini and of a marine species allied to Nais, contain really light-refracting bodies, and connect with the nervous centre by particular nerves. The last of these Annelides has similar pigment specks also upon each side of the segments of the body, which receive each a distinct nerve from the ventral marrow. Is not this species identical with the Nais picta described by Dujardin (Ann. d. Sc. Nat. 1859, XI. p. 235, Pl. VII. fig. 9) ?

8 Cleptina has two, four or six eyes; Nephelis, eight; and Haemopis and Sanguinina, ten; while with Branchiobdella, they are wanting. With this family (the Hirudinei), these organs are always symmetrically arranged upon the neck.

9 At least with Sanguinia officinalis.
enveloped with a layer of black pigment. Each of these bodies receives a nervous filament from the cerebral ganglion. Undoubtedly, these filaments are optic nerves, and the cylindrical bodies are light-refracting and light-concentrating organs.

Many of the Dorisbranchiata are entirely without eyes, having only the eye-specks; but others, belonging to the Amphipinnae, Nereidae, Enniidae, and Aphroditae, have two to four very distinct eyes. In these, there is an eye-ball invested with a black or brown pigment layer: and this layer often has, above, a very distinct round pupillary opening, covered by the skin, which bulges out like a cornet. At the central portion of this layer, there is concealed a transparent body, which is very probably surrounded by a retina-like expansion of the optic nerve. The optic nerves which are given off usually from the upper surface of the brain have, after a short course, and before entering the pigment layer of the eye, an enlargement. It is said that with some the light-refracting body and the pupillary opening are wanting. In such cases, the eyes could only distinguish light from darkness.

III. Organs of Hearing.

§ 151.

Although it has never been doubted that the Annelides can perceive sounds, yet it is of late only that the attention has been directed to the locality of the auditory organs. The two vesicles, which, with some Chaetopodes, are situated near the osophagial ring, and contain crystalline bodies, may be regarded as simple Vestibula, containing many otoconia.

5 Weber was the first to show that the black specks of Sanquisuisita officinalis were really eyes (Meckel's Arch. 1827, p. 301, Tab. XI. fig. 24). This has been confirmed by Brandt (Med. Zool. I. p. 251, Tab. XXIX. A. fig. 10-12), and more recently, Wagner has discovered in the interior of the pigment layer, a transparent body, composed, he thinks, of two parts, a crystalline lens and a vitreous portion; see Wagner, Lehrbuch, d. vergleich. Anat. 1833, p. 429; also Lehrb. d. speziellen Phys. 1835, p. 383, and Icon. physiol. 1839, Tab. XXXVIII. fig. 16.

6 Brandt has been able to trace the ten optic nerves of Saneulisuisa officinalis from the brain even to the eyes (Med. Zool. loc. cit. p. 250, Tab. XXIX. B. fig. 2.)

7 With Ulysses, Aricia, Areumycta, and Cirripedus, the eyes are wanting. With Conioeta, and Nephrys, there are only simple pigment specks upon the head. With Enteina, Phylodoca, and Alcicopa, there are two eyes; and four with Nereis, Syllis, Hesione, and Amphipinnae. The genus Alcicopa is well suited, from its large size, for the dissection of these organs.

8 For a most detailed description of the eyes of Nereis, see, we are indebted to Muller (Ann. d. Sc. Nat. X. XII. 1831, p. 22; Pl. IV. fig. 6 10), and Wagner.

9 [§ 150, note 6.] For further details on the ocular organs of the Hirudinei, see Moguin-Tandon, loc. cit. Ed. 1846, p. 80, Pl. VII. fig. 11. According to him, they contain neither a lens nor a vitreous humor, and are only light-perceiving organs.

10 For Legdid (loc. cit. p. 120) who makes the following statement upon the nature of these bodies with Pisicola: "They receive no nerve, neither do they contain a light-refracting body. I regard them as simple organs, wholly analogous to the corresponding pigment dots on the pedal shield, with which they also correspond in color and distribution."—Ed.
CHAPTER V.
DIGESTIVE APPARATUS.

§ 152.

The digestive canal of the Annelides, which is organized after very different types, opens always at the anterior part of the body by a mouth, and at the posterior part by an anus. It is situated upon the axis of the body, and is usually straight, rarely having convolutions. Often it is divided into many sections, to which the names of pharynx, oesophagus, stomach, and intestine, may be given. The mouth is usually surrounded with thick lips, and, with many Capitibranchiata, it has very erectile tentacles and cirri, which may be not only tactile but prehensile organs. With others of this group, the food is taken in by the action in the water of the ciliated branchial rays which surround the mouth in an infundibuliform or spiral manner. But usually the food, both soft and solid, is seized by the protuberant lips, and swallowed by the very muscular pharynx. Many Annelides can also suck in liquid food through their organs of deglutition. The stomach and intestine is lined with ciliated epithelium. The intestinal canal, whose walls are in general very thin, is either closely embraced by the parenchyma of the body, or, when there is a cavity of the body, is supported and constricted by numerous muscular septa.

I. Organs of Deglutition and Mastication.

§ 153.

The mouth of the Nemertini is situated upon the ventral surface, and usually at some distance from the cephalic extremity. It is a longitudinal orifice opening into a long, muscular and very spacious pharyngeal tube. This tube is intimately united with the parenchyma of the body, and after passing a short distance backward, joins directly with the intestinal canal. With many Hirudinei, the mouth is at the anterior extremity. Its anterior border projects so as to form a kind of lip, which the animal can voluntarily change into a sucker. Other species have a complete oral sucker,

1. *Terebella*, *Amphitrite*, and *Siphonostomum*.
2. *Sabella*, and *Serpula*.
3. Many Hirudinei.
4. This is true of the Hirudinei, and many Nemertini.
5. With the Chaetopoda.

Thus *Duges, with Polystemma (Prostoma) armatum* (Ann. d. Sc. Nat. XXI. 1850, p. 74, Pl. II. fig. 5), and *Quadreaqyes, with Nemertes mundilla* (Jean. d. Règne anim. de Cuvier, Zooph. Pl. XXXIV. fig. 2), regard the long canal which opens at the cephalic extremity, as the pharyngeal tube, and the spines at its base as mandibulary organs; while *Orsted* (Beschreib. d. Pflanzwärmer, p. 22, Taf. III. fig. 41, 49, 50) regards this whole apparatus with *Tetrastemma* as a cephalary organ (see below). In my opinion, the animals here cited do not belong even to the Nemertini.

Thus *Borisitsia* (*Rathkei, loc. cit. p. 90, Taf. VI. fig. 10, 11*) and *Polita* (*Delia Chiage, loc. cit. II. p. 407, Taf. XXXVIII. fig. 3, 4, or Isis, 1832, p. 645, Taf. X. fig. II. 3, 4*). With *Strebeckia annulata*, I have found the pharyngeal tube arranged in the same way.
entirely distinct from the rest of the body. These suckers serve not only as locomotive organs, as the one, for instance, which is situated at the posterior end of the body, but also for the drawing in of liquid food, and particularly blood. For this purpose, many Hirudinellae have a short and spacious pharynx, possessed of muscular walls, which are blended with the parenchyma of the body, and which are armed with horny teeth, by which they cause the wounds necessary for sucking the blood. With Branchiobdella, the pharynx has horny upper and lower jaws, of a pyramidial form. With Sanguisuga, and Haemopis, on the contrary, the base of the pharynx has three fleshy swellings, the projecting arciform border of which is edged with bipectid teeth. In this respect, Clespiæ is quite different. The pharyngeal tube is very long, and from its base a movable fleshy tube can be protruded out of the mouth, and which the animal can use as a proboscis. With the Abranchiati, and Capitibranchiati, the pharynx is simple, short and muscular, and presents nothing remarkable. With the Dorsibranchiati, it is very muscular, of variable length, and stretches freely into the cavity of the body. By the aid of special muscles, it may be folded upon itself, and project far out of the mouth. With many Annelides, the pharynx has a horny, masticatory apparatus of sometimes a very complicated structure, and which, when the pharynx is protruded, often extends out beyond it, and serves as a prehensile organ. These two, four, seven, or eight jaws always move laterally upon each other. They are usually curved like hooks, and denticulated upon their concave side. When numerous, they are of dissimilar forms with the same individual.

II. Intestinal Canal.

The intestinal canal of the Nemertini passes directly from the mouth to the anus, without forming a stomatal dilatation. Its walls are closely united with the parenchyma of the body, and its internal surface throughout is thickly set with annular folds, which, projecting far into the canal, form there pouch-like divisions.

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5 Pisecola, and Pontodella.
6 See Hentze, Muller's Arch. 1835, p. 575, Taf. XIV. fig. 1.
7 See Moquin-Tandon, Monogr. des Hirud. p. 43, Pl. I. fig. 2, Pl. IV. V. ; Brandt, Med. Zool. II. p. 214, Taf. XXIX. A. fig. 15-18, 21, Taf. XXV. B. fig. 15-17. The swellings of these branches are carried in front during suction, so as to resemble a three-rayed star—the form of the mouth which they produce.
8 See Moquin-Tandon, loc. cit. Pl. IV. This proboscis quite reminds one of the pharyngeal tube of the Phanerogamæ, which also can be protruded from the mouth, but without being reversed.
9 This pharyngeal tube is short with Amphi—and Peripatus; but very long with Amphiplosis, Polygon, Herseia, Phyllodoce, Glyceria, and Gonidia; see Audouin and Milne Edwards, Researches, &c., loc. cit. That of Amphiplosis, Polygon, Amphinomo, and others, has been regarded as a stomach; see Trewirruss, in Tiedemann's Zeitschr. f. Phys. III. p. 161, Taf. XI. fig. 9, 10, k; Grube, Zur Anat. d. Kiemen—wurmer p. 64, et seq. and Stannius, Ida, p. 982. But the position, structure and muscular appara-

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10 According to Rathke (Denniz. Schrifl. loc. cit. p. 90), these transverse folds do not exist with Borelinia striata, except when the body is shortened by contraction, and they disappear when it is again extended. But it did not appear thus to me with the numerous folded intestine of Meeckia annulata. Delile Choix had already observed these folds with Polia spinacea, but figured them as isolated pouches (Memorie, loc. cit. II. p. 407, Tav. XXXVIII. fig. 5, 6, or Isab. 1832, Taf. X. fig. 11, 5, 4). According to Quatrefages (Ann. d. Sci. Nat. VI. 1846, p. 243), the intestinal canal of the Nemertini, which occupies the axis of the body,
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With the Hirudinei, the intestinal canal varies very much, especially as to the number and volume of its appended caeca. Its very narrow canal opening is upon the back directly above the pedal sucker. With Nephe-
lis, the canal is simple and gradually enlarges from before backwards, but has no caeca.

With Branchiobdella, it is deeply constricted in several places. With Pontobdella, it is simple with its two anterior thirds, but there is a caecum on each side of its remaining portion. This last is also true of its posterior third with Haemopis, Clepsine, and Sanguisuga. With this last genus, the other portions of the canal are divided by ten or eleven constrictions into as many parts which send off on each side short caeca; while that of Clepsine has on each side five or six caeca, all of which may be ramified. There is a kind of valve directly behind the last two caeca, and so the part of the intestinal canal in front of this may be regarded as a stomach and a small intestine, while the remaining portion behind it, represents the rectum.

With the Abranchiati, the intestinal canal is short, and its oesophagus which is usually narrow passes into a muscular pharynx, which leads into a stomachal dilatation. Upon these parts follow the remaining portions of the intestine which are separated from each other by the transverse septa of the body and often resemble the stomach. With a few species only, the stomach is remarkable for its thick, muscular walls.

With some of the Capitibranchiati, the digestive canal arises directly behind the oesophagus and has bulging portions like those of the colon, assuming, posteriorly, sometimes a spiral form. With others, the oesophagus is continuous directly into the intestinal canal, which, free and unattached by diaphragmatic septa, makes many turns in the cavity of the body, and by constrictions is divided into a stomach, small intestine, and rectum.

With many Dorsibranchiati, the intestine follows directly upon the oesophagus, and is either straight and divided by constrictions, or assumes a spiral form or is without constrictions and irregularly tortuous. With others, the portion of intestinal canal between the pharynx and in-
testine, receives the excretory ducts of glandular appendages and is therefore, more properly a stomach than an oesophagus. 16 With many, the stomach and its appendages are wanting, but then the entire canal stretching directly across the cavity of the body has on both sides long analogous appendages which sometimes consist of dilated sacs, so that these appendages have wholly the aspect of caeca. 17

III. Glandular Appendages.

§ 155.

The glands appended to the digestive canal of the Annelids may be divided into the salivary and hepatic organs. The first of these are sometimes absent, but the last are never wanting.

The organs regarded as salivary glands are attached either to the pharynx or to the beginning of the intestinal canal. With the Nemertini, they are absent. But with Sanguisigua, as abdominal salivary glands, may be regarded the many groups of round corpuses which surround the commencement of the intestine, and whose excretory ducts open into it by many orifices, after anastomosing together. 18 With Lumbricus, there is a long lobular body on each side of the pharyngeal tube which secretes a whitish liquid, and which is analogous perhaps to an oral salivary gland. 19 The four pairs of transparent vesicles, which, with Enchytraeus, open at the interior extremity of the oesophagus, are possibly of the same nature. 20 With Siphonostomum, there are two ribund-like caeca which pass along the oesophagus and open separately into the oral cavity. 21 With many Dorsibranchiata, the commencement of the intestine has two glands of probably a pancreatic nature. 22 It is difficult to decide as to the hepatic or salivary nature of the numerous and usually white appendages, which belong to both sides of the whole alimentary canal of the Aphroditae. With Polynoe, these consist of six cylindrical, caecal, and sometimes bifid tubes, lying between the muscles of the walls of the body. 23

* With Aphrodithe hystricx, there are twenty of these tubes on each side.

16 Nereis; see Rathke, De Boggero et Nereide p. 35, Tab. II. fig. 7, 8.
17 With Aphrodithe hystricx, and acuteata, the intestine has on each side twenty glandular appendages with long peduncles. In this last species, these appendages are caeca also, for they have at their extremities sacculiform dilatations filled with chymus; see Pott, Miscell. Zool. p. 85, Tab. VII. fig. 11; Trewirkus, in his Zool. f. Physiol. III. p. 162, Tab. XII. fig. 9, 10; and Milne Edwards, in Cyclopedia. Anat. and Phys. I. p. 168, fig. 79.
19 Morren, loc. cit. p. 129, Tab. X. XI. (Lumbricus terrestris).
20 Heute, in Muller’s Archiv. 1837, p. 79, Tab. VI. fig. 6, d. d.
21 Rathke, Darmzig. Schriften loc. cit. p. 57, Taf. V. fig. 5. c. c.
22 With Nereis, these two salivary glands communicate by two narrow ducts with that portion of the intestinal canal which should be regarded as a stomach; see Rathke, De Boggero et Nereide, p. 35, Tab. II. fig. 7, g; 8. Grube has found these two appendages at the beginning of the intestinal canal with Arencicala (Zur. Amat. d. Kiemenwurmer), p. 6, Taf. I. fig. 1, 6, h.; and with Ammottypane (Nov. Act. Acad. XX. p. 157, Tab. X. fig. 13, 15, b.). See also Milne Edwards, in the Annales d. Sc. Nat. X. 1838, PI. XXI. fig. 1, j. (Nereis), and PI. XXII. fig. 1, c. c. (Arencicala); and Wagner, Icon. zool. Tab. XXVII. fig. 38, g; 9. (Nereis).
of the intestinal canal; these are narrow and their botryoidal extremities lie in the interstices of the dorsal wall of the body.

With Aphrodite aculeata, the structure is analogous but differs in that these appendages have more the aspect of coeca with thin walls, and have not the ramified diverticula except in their central part and between the already-mentioned saccular dilatations. (6)

As an hepatic organ may be regarded with more certainty a particular tissue colored in part brownish yellow, and partly greenish yellow, which closely surrounds the whole intestinal canal of most Annelides. Carefully examined, this tissue is found composed of closely-aggregated glandular sacs which empty their contents into the intestine either directly, or by many common excretory ducts. (6) This contained liquid is, with most species a transparent fluid in which are suspended brown granules, and it resembles the bile of the higher animals.

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CHAPTER VI.

CIRCULATORY SYSTEM.

§ 156.

This system is highly developed with the Annelides. The blood is usually colored, and the vascular system, remarkable for many peculiarities, is complete and closed.

This system may be divided into a central and a peripheric part.

The first consists of large contractile vessels taking the place of a Heart. There are also various heart-like organs in the shape of varicose dilatations upon the course of the contractile vessels. The principal vessels have a longitudinal course, occupying the whole length of the median line of the body,—one as a dorsal, and the other as a ventral vessel.

With many Hirudinei, there are also lateral vessels. The dorsal and ventral vessels unite at both extremities, beside anastomosing by transverse branches in the separate segments.

When there are lateral vessels, these also connect with the median ves-

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7 See Pallas, Drcnavanu, Milne Edwards, loc. cit., and Gruber, loc. cit. p. 54.
8 According to Henle (Muller's Arch. 1837, p. 81, Taf. VI. fig. 2), this glandular envelope forms a villous envelope about the intestine. This is also true of Lumbriculus, Lumbriculus, Nais, and Chaetogaster. The glandular sacs are greenish with Branchiobdella (Henle, loc. cit. 1838, p. 579), yellowish with Amphitrite (Ruhle, Darmg, Schrift, loc. cit. p. 65). With Sanguinina, the excretory ducts of the hepatic sacs inter-anastomose and form a kind of network around the stomach and its coeca; see Brandt, Med. Zool. p. 247, Taf.

* [§ 155, note 8.] The hepatic organs with the Annelides have been successfully studied by Will (Muller's Arch. 1845, p. 508), who has used chemical tests. He has found the glandular layer

XXIX. A. fig. 28, 29. With many, this hepatic layer envelopes also the blood-vessel upon the dorsal surface of the intestine. It is possible that the yellow canal described by Morren, with Lumbricus terrestrial as Chlorangena, is only this hepatic mass (loc. cit. p. 142, Tab. XV. XVI). Another canal which is traversed by blood-vessels and closed at both extremities, and which is contained in a longitudinal enlargement upon the internal surface of the intestinal canal, and is called by Morren, Typhloelis (loc. cit. p. 138, Tab. XI. XII. XVI. XVII) may perhaps be regarded as a receptacle of sipho. (Lumbricus, Nais), and the long, thread-like and coecal glands (Hirudo, Haemopis, Aulacostoma, Helluo, Piscicola, Clepsis) which surround the intestinal canal, to be organs of this nature.—Ed.
sel by transverse anastomoses. The peripheral vessels arise by means of a capillary net-work, from the most various points of the longitudinal and transverse vessels. The circulation has on the whole a determinate direction,—the dorsal vessels force by a kind of peristaltic movement the blood from behind forwards into the ventral vessel, which returns it into the dorsal vessel. The blood can, however, pass from the dorsal to the ventral vessel by a much shorter way,—by traversing the capillaries, or directly through the transverse anastomoses. It is, moreover, very probable that the course of the blood in the transverse vessels is not always in the same direction, and that it may under certain circumstances pass from the ventral into the dorsal vessel. This makes it difficult to decide which of these vessels are arteries, and which veins. The respiratory organs, which usually form the limit between the venous and arterial systems, are, with most Annelides connected with the transverse vessels, and therefore throw no light upon this doubtful point. From the multitude of these transverse anastomoses, it must appear impossible to distinguish the arterial from the venous blood, and the distinction of veins from arteries with most Annelides must be wholly arbitrary.

The blood of the Annelides, although red like that of the vertebrates, is, however, quite different. It is composed of a liquid containing globules. These last, which are always colorless, of unequal size, and of a spherical form, are granulated on their surface. The blood liquid is either colorless, or contains a coloring matter, which is usually red, but sometimes yellow or green.

§ 157.

With the Nemertini, whose blood is red but as yet imperfectly known, the circulation appears to be due to two cardiac dilatations concealed in the cephalic extremity.

The Hirudinei have, beside the two median vessels, two lateral ones also, which intercommunicate by very numerous transverse vessels. From the contractions of these vessels, the blood is driven sometimes forwards, and

1 For the blood-globules of the Annelides, see Warner, Zur vergleich, Physiol. d. Blutes, Hft. 1. p. 23, Hft. II. p. 39. According to him, those of Terebellina (ibid. Hft. I. fig. 8) are pale red, circu-
lar discs. Here the exception is remarkable, sup-
opposing there was not an error of observation. It appears that beside the blood which circulates in the vessels the fluid contained in the visceral cav-
ity of the Chaetopodes plays also an important part in the act of nutrition, for the eggs and the spermatic particles which with these animals are often detached from the ovaries and testicles at a time when still quite imperfect, attain their com-

2 According to Milne Edwards (Ann. d. Sc. Nat. X. 1859, p. 197), the blood of the Nemertid is color-
less.

3 The vascular system of Polygemma has been distinctly seen by Dougés (Ann. d. Sc. Nat. XXI. 1839, p. 75, Pl. II. fig. 6), and by Orsted (Hes-
chreib. d. Platowärmer, p. 17). It is composed of many longitudinal vessels, which intercommunicate not by transverse ones, but by acute anastomo-
ses at the cephalic extremity, and by two hearts in the cervical region. According to Orsted, these

hearts are divided into two chambers, the anterior having deep-colored blood, while that of the posterior one is more clear. This arrangement has led this naturalist to regard as hearts the bodies described by Rathsé, with Barbotia striata, as cerebral gan-
glia, and as blood-vessels, the nerves which are given off from them laterally (see above, § 148, note 2). But if Quatrefages' figures of the nervous and vascular systems of Nemertes mandilla are exami-
ned (Régane de, dc Cuvier cd. illustr. Zoophytes. Pl. XXXIV. fig. 1), it will be seen that there are here three main trunks, a median and two lateral. These last accompany the lateral nerves, while a bifurcating vessel which passes from the median to the two lateral trunks, embraces closely, in a loop-
like manner, the two cerebral ganglia, so that they easily escape observation. This is perhaps true also of Bartonia.

4 The sanguaneous system of Sanguinula has been very carefully described by Brunn (Med. Zeit. XX. p. 317, Tal. XXIX. B.); see also Bogja-
mas, in the Isles, 1815, p. 280, Tal. XXVI. fig. 3. 4. With Nepheles, there are only two lateral vessels and an abdominal one, lying along the ventral me-
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sometimes backwards and oscillates from one side to the other, through the transverse vessels. \( ^4 \) With most genera, the blood is red, being colorless with a few only, and it is always poor in corpuscles. \( ^5 \) The Chaetopodes have no lateral vessels. Their circulation is often due to pulsatory organs, and there is a great variety in the disposition of their vascular trunks and sinuses.

With the Abranchiati, the dorsal vessel lies close upon the intestinal canal, and is almost wholly enveloped in the hepatic tissue. At the anterior extremity, it divides in many bifurcating branches, which, after encompassing the pharynx, unite below it, and form the ventral vessel. \( ^6 \) This vessel accompanies the ventral cord to the posterior extremity, and connects with the dorsal vessel by bifurcating branches, as before. \( ^7 \) The transverse anastomoses connecting the dorsal and ventral vessel, form at each segment simple, or torose canals. \( ^8 \) With the Small Lumbricini, these are usually

\[ ^4 \text{The irregularity of the blood-currents has, undoubtedly, given rise to the numerous different opinions upon the circulation of these animals; see Du
ges' Ann. d. Sc. Nat. XV. 1828, p. 596; Weber, in Meckel's Arch. 1828, p. 539; Muller, Ibid. p. 24; and in Burdach's Physiol. 11. 1832, p. 14;} \]

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\[ ^8 \text{With the Small Lumbricini, these are usually}

\[ ^9 \text{With the Small Lumbricini, these are usually}
only in the anterior segments of the body. With the genus \textit{Lumbricus}, the cardiac organs consist of five to nine pairs of moniliform, transverse canals, situated above the stomach, and whose pulsations are very distinct. With all the Abranchiati yet examined, the blood is red.

With the Capitibranchiati, there are often two dorsal vessels, one immediately subcutaneous, the other lying, as usual, on the intestine. This duplicity of the dorsal vessel is observed particularly with those species which have a coiled intestinal canal. In this case, there is also a second ventral vessel accompanying the coils of the intestine. All these longitudinal vessels interanastomose very frequently, and send many transverse branches to the intestine and the walls of the body, where they blend with the capillary system. Not unfrequently, the dorso-intestinal vessel is dilated at its anterior extremity, above the pharynx, into a large, pulsatory, heart-like canal, which sometimes has two lateral arcuate, sinuses situated at the commencement of the intestine. The extremity of this vessel sends off, right and left, many branches to the branchiae, which are situated in this region. Leaving these organs, these vessels are distributed, some in front to the tentacles, and to the other organs surrounding the mouth; while others pass below to unite with the ventral vessel. As the blood is thrown from behind forwards in the dorsal vessel, and thence passes into the branchiae, this vessel may be called a dorsal vein, and its dilatation a branchial heart; while the ventral vessel, which receives the returning blood from the branchiae, would be an abdominal aorta. But there are other reasons for this view. The dorso-intestinal vessel, from its intimate connection with the liver, might well serve the function of a \textit{Vena portarum}, while the close union of the ventral vessel to the ventral cord, is undoubtedly for the purpose that the latter, as a central nervous mass, may receive arterialized blood directly from the branchiae. With these animals (the Capitibranchiati), the blood is red in some, and green in others.

The Dorsibranchiati often have double dorsal and ventral vessels, two of which belong to the intestinal canal, and two to the walls of the body. With some, these longitudinal vessels are divided into two or three branches. The principal dorsal vessel is sometimes dilated at its anterior extremity, above the pharyngeal tube, into a cardiac sinus, to which, at the beginning of the intestine, there are added two lateral, arcuate dilatations.

9 \textit{Enchytraeus}, Chaetogaster, and Nais. The vascular system of \textit{Enchytraeus} and \textit{Lumbricus} is very remarkable in this respect. Instead of transverse anastomoses, there are, in each segment of the body, two vessels which pass off from the dorsal trunk, and divide into many coecal branches; see \textit{Treubiana}, \textit{Boeckali}, and \textit{Zoea}, loc. cit. p. 60; and \textit{Grube}, in \textit{Wiegmann's Arch.} 1844, l. p. 205, Taf. VII, fig. 1, 2, 4.

10 See \textit{Duges}, loc. cit. Pl. VIII, fig. 1, and \textit{Marren}, loc. cit. p. 192, Tab. XX.-XXIII., XXI.-XXIV. fig. 1.

11 \textit{Milne Edwards} has made very beautiful researches upon the vascular system of the Capitibranchiati; see Ann. d. Sc. Nat. X. 1838, p. 193, Pl. X. XI.

12 \textit{Amphiphrutes} and \textit{Siphonostomum}; see \textit{Rathk}i, Danzig. Schrif. loc. cit. p. 76, 88, Taf. V. fig. 4, 5.

13 With \textit{Terebella}, there is a vascular heart and two lateral sinuses; see \textit{Milne Edwards}, loc. cit. Pl. X. XI. fig. 1. With \textit{Siphonostomum}, there is a similar cardiac dilatation upon the pharynx, and it is divided into two chambers by a well-marked constriction at its posterior part; see \textit{Rathk}i, loc. cit. p. 80, Taf. VI. fig. 5, f. g.

14 With \textit{Terebella}, \textit{Amphiphrutes}, and \textit{Serpula}, the blood is red; with \textit{Siphonostomum}, \textit{Chloroma}, and some species of \textit{Sabella} and \textit{Serpula}, it is green.

15 We are indebted to \textit{Milne Edwards} for very detailed accounts of the vascular system of the Dorsibranchiati; see Ann. d. Sc. Nat. loc. cit. Pl. XII.-XIII.; see also, for that of \textit{Arenicola}, \textit{Staussi}, in \textit{Muller's Arch.} 1840, p. 357.

16 With \textit{Enbus sucina}, there is a double dorso-intestinal vessel (\textit{Milne Edwards}, loc. cit. Pl. XI. XII. fig. 2, 3); and a double ventral one with \textit{Nepthys Hombergi}. With \textit{Arenicola}, there are three ventral vessels accompanying the ventral cord (\textit{Muller}, in \textit{Berdistique's Pays}, loc. cit. p. 147), and with \textit{Amphiphrutes}, \textit{Grube} has found three dorsal ones beside, all widely separated from each other.

17 \textit{Enbus}; see \textit{Milne Edwards}, loc. cit. Pl. XII. fig. 2. The vascular system here resembles that of \textit{Terebella}.\[9]
These last are sometimes found alone. With many of these Annelides, the transverse vessels are dilated, before branching, into real branchial hearts. As their branchiae are variously situated among the transverse anastomoses, the distinction between the arterial and venous blood is not as marked as with the Capitibranchiati; it must be arbitrary, as with the Hirudinei and Abranchiati. The blood is usually red, but sometimes is yellow or nearly colorless.

Chapter VII.

Respiratory System.

§ 158.

With the various families of the Annelides, the respiratory organs are formed after wholly dissimilar types.

With the Nemertini, they are least developed, for, excepting two longitudinal fossae upon the sides of the cephalic extremity, there are no organs which can be regarded as of this nature.

These two respiratory cavities are of variable depth, and their lateral borders are so approximated as to have the aspect of a longitudinal opening, and with some they are situated so far out on the cephalic extremity as to be blended together. They are lined with a delicate ciliated epithelium, quite different from that covering the rest of the body, and by the vortex actions of which, fresh water is brought constantly in connection with the blood. Considering the smallness of these organs, it is very probable that the whole skin has also a respiratory function.

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18 Aresicola; see Milne Edwards, loc. cit. Pl. XIII.
19 Eunicæ; ibid. Pl. XII. fig. 2.
20 With Eunicæ, Nephtyæ, Glycera, and Aresicola, the blood is red; with Phyllodoca, it is yellow; and it is nearly colorless with Aphrodite, Polynæ, and Sigalion; see Milne Edwards, loc. cit. p. 198.
1 See Müller, Zool. Danica. Tab. LXVIII. fig. 1-4. (Tetrastræma (Planaria), viroidea); Delia Chioje, Mem. loc. cit. Tav. LXXXVIII. fig. 8, a (Polia genticulata); Quay and Gaimard, Atlas Zool. de l'Astrolabe Zooph. Pl. XXXV. fig. 10 (Borlasia viridis); and the Dict. d. Sc. Nat. LVII. Art. Veræ, p. 574. Pl. Parentomœnares, Nemertès, fig. 1, 2 (Borlasia anglica, and Cerebratulus bilineatus); also Huchéz, Isis, 1839, Tal. VII. fig. 1-3. Notaspermus drepanensis.
2 Tetrastæma viroidea, Polia genticulata, and Micrura fuscicolata (Ehrenberg, Symb. phys. Phytoplana Tab. IV. fig. 4. t. 1. g.).
3 See Quatrefages, Régne anim. illustr. Zooph. Pl. XXXIV. fig. 1. b. b. (Nemertes Camillæ).
4 Rathé (see above, § 149, note 1) is of the opinion that these two cephalic fossæ are the seat of touch; but the view of Orsted (Heschel, d. Physiowarm., p. 18, 77), who think them of a respiratory nature, is, perhaps, the more correct. In support of this last, is the fact of the presence of ciliated epithelium, and of a very large blood-vessel directly beneath them (see Quatrefages, loc. cit. Pl. XXXIV. fig. 1, g. g. (Nemertes Camillæ)) and which, in many Nemertini, is clearly seen through the thin epithelium; see Müller, Zool. Dan. Tab. LXVIII. (Tetrastræma viroidea); Delia Chioje, Mem. Tav. LXXXVIII. fig. 3 (Polia genticulata), and Isis, 1839, Tal. VII. (Notaspermus drepanensis).

With the Hirudinei, and Lumbricini, the peculiar canals found in the abdominal cavity may be regarded as internal branchiae, or as aquiferous vessels.

The intimate structure of this aquiferous system is difficult to unravel with the Hirudinei. It is most easily observed with the Branchiobdella; here there are only two pairs of curved canals whose inner surface is ciliated. One of these pairs opens upon the ventral surface at the beginning of the second third of the body, while the other opens at the extremity near the median line. Each of these four canals is dilated just before its external opening into a round, yellow cavity, from which pass off many loop-like vessels. With the other Hirudinei, these organs in pairs are more numerous, and situated one after another from the second third to the extremity of the body.

It is remarkable that the ciliated epithelium lining these canals with Branchiobdella, is absent in all the other species.

The structure of the respiratory system of the Lumbricini is not less difficult to be understood. With all the genera there are, at the commencement and on each side of the intestine, very tortuous canals which open upon the ventral surface, by a narrow orifice near the median line. These canals are lined with long cilia which have an undulatory movement; they also are colorless and sometimes have dilatations before opening externally, but they never contain air, so that the terms tracheae or pulmonary cells, have been erroneously applied. Often they float loosely in the cavity of the body, and their free extremity has an orifice surrounded by long vibratory cilia. With some, however, they terminate by thickly-

1 See Hente, in Muller's Arch. 1835, p. 578, Taf. XIV. fig. 1. This epithelium would undoubtedly favor the constant renewal of water in these canals.

2 With Sanguisuga, there are seventeen pairs of these organs. They have been taken by Brandt (Arch. Zool. H. p. 251, Taf. XXI. A. fig. 85-87) for organs of special secretion, since he has seen a whitish liquid escape from their ventral orifices. The rhomb-like organ of these Annellides is not, moreover, as is usually supposed, a simple canal, but is composed of numerous interwoven and frequently interspersing canals, having no trace of ciliated epithelium.

From Dupres' remark (Ann. d. Sc. Nat. XV. 1828, p. 385, Pl. VIII. fig. 2), I think it probable that this net-work is formed of blood-vessels which are occasionally empty, for I have always found them colorless.

In this case, the real aquiferous canals are probably concealed in the net-work, and from their want of ciliated epithelium not easily seen.

With Nephela vulgaria, I have seen the same number of internal branchiae as with Sanguisuga. Here, the aquiferous system appears as a knot of colorless, non-ciliated canals connecting with a vesicular pouch which is filled with red blood; so that in the posterior third-thirteenths of the body there is a double row of seventeen sanguineous sinuses, inside the lateral vessels. These sinuses, already carefully described by Muller (Michael's Arch. 1828, Taf. 1. fig. 1), take no part in the pulsations of the main vessels, and are not alternately emptied and filled during the transverse circulation of these animals.

A very interesting fact to me, is the existence with this Nephela, of a multi-branchiate, reticulated, ciliated, colorless organ in the interior of these sanguineous sinuses. 3

3 See Hente, in Muller's Arch. 1837, p. 84, Taf. VI. fig. 7, 8, v. w (Eunychoturus); and Grauhjhen, Nov. Act. Acad. Nat. Cur. XI. 1823, p. 258, Tab. XXXVI. fig. 1, i. XIV. 1828, Tab. XXV. fig. 3 (Nais and Chartognathus).

4 An aqueous respiratory fluid circulates in these canals undoubtedly by the aid of cilia. The terrestrial Lumbricini which live only in the damp earth obtain this fluid therefore.

5 I have observed this with Stenurus variegatus, Lumbriculus variegatus, Nais linguis, He also states as conclusions:

1. The non-communication of the abdominal vessels with the branchiae.

2. The existence of a subcutaneous lymphatic vessel.

3. The origin from this vessel of trunks which go to the branchiae. — En.
arranged loops. With *Lumbricus*, these aquiferous canals are surrounded by a very distinct vascular net-work, which has a botryoidal aspect from its numerous pedunculated, vesicular dilatations which are filled with blood.  

§ 160.

With most of the Capitibranchi, and Dorsibranchi, the respiratory organs consist of external branchiae, which are very apparent, although having variations in their development. They always consist of lobules or filaments covered with ciliated epithelium, and in which are very considerable vessels as branchial arteries and veins. The branchiae are here always situated between the venous and arterial systems, so that a portion of the whole blood is made to pass through the respiratory organs.

It is possible that the two bundles of tentacles which are found with many Capitibranchi, as infundibuliform, or spiral tufts, are also respiratory; for their vibratory organs not only draw in food, but also produce a constant change of the water.

Other Capitibranchi have distinct and exclusively respiratory organs in the cervical region, which are either dendritic, or semi-pinnate.

With the Dorsibranchi, nearly every segment of the body has branchiae upon both sides of its dorsal surface. These are so simple and rudimentary with the Arieae, and Nereideae, that they consist only of simple lobules, exactly resembling the cirri of the feet.

*Echiura* *albida*, and others. Those canals thus situated remind one of the trebling organs of Rotatoria, connecting the two lateral canals with the cavity of the body; see above, § 138.

6 With *Lumbricus terrestris*, and its allied species, I have as yet been unable to find any orifices of the aquiferous canals. *Hentle* also (Mulder's Arch, 1835, p. 589) has always found them looped upon themselves. They may however exist, although they have eluded the notice of Hentle and myself, for the respiratory organs of *Lumbricus* are so difficult to study that there is yet no description or figure giving any idea of their complexity; see the poor figures of *Lumbricus terrestris* by *Leo* (loc. cit. p. 25, Tab. I. fig. 4), and *Morren* (loc. cit. p. 52, 114, Tab. XIV. XVI.). Those of Hoffmeister, although more detailed, are scarcely less unsatisfactory (loc. cit. p. 15, Tab. I. fig. 35, 56). It now remains to inquire as to the relations existing between these aquiferous canals and the glands at their base which have been taken by many for mucous pouches. I cannot, for my own part, perceive that these glands with the *Lumbricus terrestris*, excrete any liquid whatever upon the ventral surface. On the other hand, I have often seen escape from the back of this animal, a watery liquid which was only the contents of the cavity of the body, issuing through small orifices upon each side of the median line between the segments of the body. Although I do not know, yet I suppose, that similar orifices exist with the other Lumbrici, and thus, by these orifices and by those of the internal branchiae, the necessary renewal of water for these last, can take place. This hypothesis appears admissible since the cilia of the aquiferous canals always move in the same way.

7 These vesicular dilatations do not pulsate, and are undoubtedly analogous of the simple sinuses which communicate with the aquiferous canals of *Nephtes vulgaris*.

1 These respiratory organs may be taken as analogous to the aquiferous vessels of the Lumbrici, which can be everted so that the internal dilated surface becomes external, and the external blood-vessels internal.

2 *Scutula*, and *Protula*.

3 *Sabellaria*.

4 *Terebella*; see *Delle Chiavi*, Mem. loc. cit. Tab. XIII. fig. 1-3, Tab. XIV. fig. 2, 10; and Milne Edwards, Ann. d. Sc. Nat. X. 1838, p. 200, Pl. X. XI. fig. 1. There are here on each side of the neck three multifilose, contractile branchiae which are placed close together. Into these a large portion of the blood of the median dorsal vessel enters by six lateral branches, while the remaining portion passes on through the dorsal vessel to the tentacles and the borders of the lips. In each branchial tuft there is a simple artery and a vein placed side by side, which anastomose at its extremity in an arcuate manner.

The returning blood from the six branchiae passes by as many veins into the median dorsal vessel, and the frequent strong constrictions and dilatations of the branchiae, certainly very much aid the current.

5 *Amphitrite*; see *Pallas*, Miscell. zool. p. 190, Tab. IX. fig. 1, 5, 6, 8, 9, 10; *Rathke*, Danzig, Schrifl. loc. cit. p. 59, Tab. V. fig. 1, 3. Here the four semi-pinnate branchiae are upon both sides of the second and third rings of the body, and each lamella contains a tightly-closed vascular network.

6 The filaments of these branchiae are very short.
It is remarkable that the branchiae are perhaps entirely wanting, with the Aphroditoe, while they are often highly developed, partly in a pectinate and partly in a fasciculate manner, with the Euniceae, Amphipoda, and Arenicolae.

with Glycera, Nereis, Lycastis, Nephtys, and others; but with Cirratulites, they are very long. With Phylloides, and Mecopus, there are flattened branchiae. But with Lumbrineris, Aglaura, and some other allied genera, these are wholly wanting; see Milne Edwards, Classif, loc. cit. The question here arises if the Dorsibranchiata which have atrophied branchiae, have not therefore internal respiratory organs. It is at least probable that the two pairs of remarkable networks surrounding the pharynx of Nereis and which have given rise to various interpretations (see Rathke, loc. cit., p. 43, Tab. II. fig. 6, 8, 8, 8, 1, s, h, and Tab. III. fig. 11; also Milne Edwards, Annt. d. Sc. Nat. X. 1838, p. 210, Pl. XII. fig. 1, e, p) are properly internal branchiae. They receive the blood from the dorsal vessel through two lateral vessels, and it is returned to the median ventral vessel by two others which are also lateral. Moreover, according to Rathke (loc. cit., p. 40), there is, between every two feet upon both sides of the segments of the body, a small orifice opening into the cavity of the body and through which water for respiration can pass.

7 Different observers have equally different opinions upon the branchiae of these animals. For my own part, I have found no trace of these organs, either internal or external with Aphroditoe aculeata, and gymnica. I suppose, therefore, that water enters the cavity of the body by orifices which are very small and difficult to be seen, and comes in contact with the entire vascular system.

Milne Edwards (Regne animal. liinse. Annul.les, Pl. X VIII. fig. 21) has figured rudimen-
tary branchial lobules with Aphroditoe aculeata, which are crenulated and concealed between the scales, and are, perhaps, invisible, when the animal is in a fresh state. Moreover, Sharpay (Cyclop. Anim. and Phys. I. p. 618), having observed with the same species a very active ciliary motion especially upon the external surface of the intestine and its cœca, it is very probable that here, as with the Asteroideæ, the respiration occurs by water entering the cavity of the body and bathing the intestine.

8 With Osaphus, and Euniceæ, the branchiae are pectinate or semi-pectinate; see Milne Edwards, Classif, loc. cit. With Diophatra, and Mecopus, each branchia consists of a single ramified fasciculus; but with the Amphipoda, and Arenico-
lae, there are several fasciculi; see Milne Edwards, loc. cit. and his plates annexed to Regne animal. de Olivier, Annulides; also Stanius, Isis, 1831, Taf. VI. With Euniceæ, the blood of the median dorsal vessel passes first into the interior intestine of the body have the form of cardiac sinuses, and by the pulsations of which it passes into the branchial vessels, whence it returns into the other two dorsal vessels by the superior lateral ones; see Milne Edwards, Ann. d. Sc. Nat. X. 1838, p. 207, Pl. XII. fig. 2.

With Amphipoda, there is at the base of each branchial fasciculus, in the cavity of the body, a Plicæus branchialis closely resembling the won-
derful networks of Nereis, and from which the blood passes into two lateral vessels which here exist; see Catal. of the Physiol. Sac. &c. II. Pl. XIV. fig. 10, or Rymer Jones, Outlines, &c, p. 215, fig. 93.

With Arenicolæ piscatorum, only the thirteen middle segments of the body have branchial fasci-
culi. These communicate with the ventral and dorsal vessels by simple lateral vessels. As there exist here at the extremity of the body between the two dorsal and ventral vessels, two cardiac sinuses, it is probable that these force the blood from before backward into the ventral vessel, and thence by the lateral vessels into the branchiæ; so that these inferior lateral vessels would be called arteries, and the superior lateral vessels which return the blood to the dorsal vessel, veins; see Milne Edwards, Ann. d. Sc. Nat. loc. cit. p. 215, Pl. XII.*

* [§ 160, note 8.] The respiratory organs of the Annelides have been much studied by Quadrifa-
ges (Ann. & Sc. Nat. XIV. 1830, p. 280) and the following is his conclusion.

1. The respiration is at first general and entirely cutaneous (Lumbrineris, Lysidice, He-
sionce, &c).

2. It is still cutaneous, but is confined or concentra-
ted upon particular rings of the body (Chaetopterus).

3. It is localized upon certain points of each ring, without the structure of these points being sensibly modified (Nereis).

4. The first degree of the specialization of the respiratory organ appears under the form of a sim-
ple cuti-de-sue, or an ampulla into which the blood flows (Glycera).

5. The branchiae become gradually character-
ized by the formation of a canal which communicates with the more or less spacious haemae.

6. These true branchiae may be distributed all along the body (Eunicea sanguinosa).

7. They may be concentrated upon a certain number of rings situated near the middle of the body (Eunicea Bellii, Arenicolæ, Hermettæ, Polydora).

8. They may be concentrated towards the ante-
rior extremity of the animal, and occupy only a few rings (Terebellæ, Posternaria).

9. Finally, they may be located wholly at the extremity of the body, and form only a double tuft (Sabellæ, Serpula).

10. In considering sometimes the entire body, sometimes each ring separately, a real distinction between the venous and the arterial system may nearly always be made out.”—Ed.
CHAPTER VIII.

ORGANS OF SECRETION.

§ 161.

Many Annelides are covered with a mucus which is secreted by small, simple follicles situated in the skin.\(^1\)

The calcareous tubes of the Serpulini, appear to be secreted by a collar surrounding the first segment of the body.\(^2\) It is not yet decided that the leathery tube in which many other Branchiati are concealed,\(^3\) is secreted by an analogous organ.

Those Capitibranchiati which form tubes with grains of sand, bits of shells, &c., have, perhaps all, an opening close behind the mouth upon the ventral surface. This opening is in connection with many glands situated at the anterior extremity of the body, which probably secrete a substance for the gluing together of the materials of these tubes.\(^4\)

CHAPTER IX.

ORGANS OF GENERATION.

§ 162.

The Annelides reproduce partly by a transverse fissuration, and partly by a sexual apparatus.

\(^1\) Similar mucilaginous follicles are arranged in curved rows with the Hirudinei, upon both the ventral and dorsal surfaces, giving the skin a granulated aspect; see Brandt, Med. Zool. II. p. 244. I have seen similar groups of follicles with the larger Lumbricini.*

\(^2\) The secretion of the calcareous matter occurs here probably as upon the border of the mantle of Mollusks.

\(^3\) Sabella, Onuphis, and Chaetopterus.

\(^4\) As secreting organs of this glue, Rathke has correctly described four yellowish glands situated, with Amphitrite, upon the ventral surface of the first and second segment of the body, and opening by a common canal at the first segment; see Daniel, Schrifft, loc. cit. p. 71, Taf. V. fig. 6, aa. fig. 2, d. With Terebella, and Sabella, the two glands near the cephalic extremity, are perhaps of the same nature. Grube, however, thinks them male genital organs; see, Zur Anat. d. Kiemenwurmer, p. 31, Taf. H. fig. 12, y; and Minle Edwards, Ann. d. Sc. Nat. X. 1838, Pl. X. n. Pl. XI. fig. 1, b. fig. 2, f.

\(^*\) [§ 161, note 1.] Leydig (Siebold and Kölliker's Zeitsch. 1849, p. 169) has described with Pisica, Clepsine, Nepheles, and other Hirudinei, cutaneous glands. These consist of an infundibuliform sac, which exactly resembles a nucleated cell, from which passes off a long, tortuous duct. With Pisica, these are situated in the cephalic and pedal shield, but in Clepsine, and Nephelis, they are also present in the skin throughout; see loc. cit. Taf. VIII. fig. 23. This structure is remarkable from its resemblance to some of the cutaneous glands of the higher animals.—Ed.
Spontaneous transverse fissuration occurs particularly with the Abran-
chiati, but has also been observed with the Nemertini, and Branchiati.

It occurs usually at the middle portion or at the border between the
second and third segments of the body. Very often there may be per-
ceived at this point, when this process has somewhat advanced, the place
where, with the two future individuals, there will be a new fissuration.
If the animal has a proboscis, tentacles, or eyes, these organs are developed
with the posterior individual before its final separation.

These animals have no trace of genital organs, while this process of divi-
sion lasts. The individuals thus produced, re-divide, and this division
continues until a certain time of the year. It then ceases, and genital organs
being developed, reproduction takes place by eggs.

The extreme vulnerability and reproductive power of many Chaetopo-
des, give rise to their frequent multiplication by artificial and accidental
division. The fragments thus produced are finally developed, and the mu-
tilated animal ultimately regains its lost parts. Some have the power of
voluntary division from the least handling of their body, and these sep-
parated parts are probably developed to new individuals.

§ 163.

Most of the Annelides reproduce by sexual organs, and the few Lumbrici-
cini which, as just observed, multiply by fissuration, have probably, like their
allied species, genital organs at certain seasons of the year.

The eggs of the Annelids present nothing remarkable; they are always
spherical, and have a chorion and thin vitelline membrane containing a
finely-granular vitellus with a germinative vesicle and dot. This

gle individual of Myriamida fasciata, which is all-
luded to Phyllobothe, produces six young by as many successively
division. According to Frey and Leuckart (Beitr. &c. p. 94, Tab. II. fig. 1),
there are with Syllis prolifera also, several young developed simultaneously, one after the other, at the caudal extremity.

See the experiments upon this subject with the Lumbrici by Research, Bonnet, Premilay, and Rosset. Dupélé (Froitz' neue Not. No. 321,
1840, p. 1) has observed a similar mode of repro-
duction with Sabello.

This has been observed by Grube, with Polia delinrata (Zur Anat. d. Kiemenwürmer, p. 59.)

Meckel's annulata has also the same property.

1 Acosoma.

2 See Wagner, Prod. Hist. gener. loc. cit. Tab. I. fig. 9, 10 (Sanguisuga and Nephelis); Stannius, in Müller's Arch. 1840, Tab. II. fig. 1, 2 (Aeci-
ecula piscatorum); Müller Edwards, Ann. d. Sc. Nat. III. 1845, p. 87, Tab. X. fig. 18, 19) has observed multiplication by transverse division
with Filograna impexa, a young animal detach-
ing itself from the caudal end of this Serpula. I have
observed a like division with a Protula, a genus al-

1 Lumbriculias, Nais, Chaetogaster and Aeolo-

2 See Johnston, in the Mag. of Zool. and Bot. I.
3 With the Nereidace.
4 Fissuration with many species of Nais, has already been noticed by O. F. Müller (Natargesch. einiger Warm-Atgen des russian und salzbogen Was-

5 See note 4. See in this connection, Shultze
(Ueber die Fortpflanzung durch Teilung bei Nais

6 The Liverknie. Ueber die ungeschlechtliche Ver-
mehrung bei Nais proboscidia, in Wiegmann's Arch. 1851, p. 283.)

7 He has carefully described this form of multiplica-
tion with animal, and according to him it is a true fissuration, and not a gemmation, as that of

8 Fissuration, and not a gemmation, as that of

9 Syllis, described by Frey and Leuckart. See fur-

10 Siphus prolifera and Autolytas prolifer. Ibid. 1852, p. 66. — Ed.

176 THE ANNELIDES.
vitellus is usually whitish or yellowish, but rarely of a more marked color.

With the Hirudinei and Lumbricii, the spermatic particles are filamentoid and very active, while with the other Annelides they have the form of Cercariae.

§ 164.

With the Hirudinei, and Lumbricii, the two sexes are always united in the same individual. The sexual organs consist of testicles, vasa deferentia, and vesiculae seminales; then, ovaries, oviducts, and the male and female copulatory organs. The female copulatory organs are upon the ventral surface of the anterior part of the body and behind the male organs—so that two individuals by placing together their anterior ventral surfaces in an inverse position, can be mutually impregnated.

The excretory ducts of both sexes are often lined with a very delicate ciliated epithelium.

from the eggs of other Annelides, in containing between the vitellus and vitelline membrane a layer of caudate cells. These cells, of variable number and size, but always of uniform size in the same egg, have often been compared, from their form, to Naviculae; see Henle, in Muller's Arch. 1836, p. 631, note, and Hoffmeister, De vernibus quibusdam, &c., Tab. III. fig. 17-18.

3 The vitellus is rose-colored, or greenish, with Cephalic, and violet with Polyneae.

The development of the spermatic particles of the Hirudinei and Lumbriici is very remarkable. The cell-contents of the parent cells, in which the spermatic particles are usually developed, disappear before these last are developed. There are then small cells grouped around a discoid nucleus. These cells lengthen out, and finally become spermatic particles, and they remain attached to the disc until fully developed. If a bundle of these is placed in water, they separate and become intertwined in the usual manner; see Henle, in Muller's Arch. 1836, p. 634, Tab. XIV. fig. 4, 6, 7, 9; Kolliker, Beitr. zur Kenntn. d. Geschlechtsverhältnisse, p. 17, Tab. II. fig. 16, 18, 19; H. Meech, Muller's Arch. 1844, p. 477, Tab. XIII. fig. 2-19 (Sangui-suga, Pentatobdella, and Branchiobdella); and Hoffmeister, De vernibus quibusdam, &c., Tab. II. fig. 6-10. From Stains' description and figures of the sperm of Arnecola (Muller's Arch. 1840, p. 375, Tab. XI. fig. 3-3); and Rathke of that of Amphiphrus auricoma (Danzig. Schrift. loc. cit. p. 67, Tab. V. fig. 13); and Quatrefoies, of that of Nemerides mandula (Regn. anim. illustr. Zooph. Pl. XXXIX. fig. 3-5), we can conclude that the spermatic particles of the other Annelides are developed like those of the Hirudinei and Lumbriici.

While in the excretory ducts of the sperm, the spermatic particles are found in bundles; and when, as at the reproductive period, many of these bundles are collected together, their very active, undulating movements give a most wonderful appearance beneath the microscope; see Morren, loc. cit. p. 175, Tab. XXIV.-XXXI., and myself in Muller's Arch. 1836, p. 42. Among the filamentous spermatic particles of Hirudinei, these of Branchiobdella are worthy of special mention. One of their extremities is delicate and spirally turled (see my observations, Muller's Arch. 1836, p. 42, Tab. II. fig. S), and terminates, according to Kolliker, by a small vesicle (loc. cit. p. 18, Tab. II. fig. 16, 6). With the Branchiobdella, the cercaria-form predominates, according to Quatrefoies (Comp. Rend. XVII. 1844, p. 424). With the Nemertei, they are either simply filamentous (Notospermus, according to Orsted, Kutsurt. einer Euth. d. Platinwurm, loc. cit. Tab. III. fig. 54) or more cercaria-form (Nemeretes, according to Quatrefoies, Regen. anim. illustr. Zooph. Pl. XXXIV. fig. 6; and Kolliker, Verhälltn. d. schweiz. Gesellsch. Beyihr. v. Berensteinz. zu Zürich. 1844, p. 94).

With the spermatic particles of the Annelides, see especially Kolliker in the Neues. Baseliker. XVIII. p. 55, 56.

8 See Bajunus, ibid. 1818, Tab. XXXII. fig. 1; Brandt, Med. Zool. 12. Tab. XXX. fig. 25 (Sanguisuga medicinae); Leo, Müller's Arch. 1835, Tab. XI. fig. 3 (Piscicola exsustiva); Morren, loc. cit. Tab. XXIX.-XXXI.; and Hoffmeister, De vernibus quibusdam, &c., Tab. I. fig. 29, 30 (Lumbriicus et Eubranchiatus).

9 [§ 163, note 4.] For the spermatic particles of the Hernella, see Quatrefoies (Ann. d. Sc. Nat. X. 1848, p. 167); he describes them as being of a cercaria-form. My own results on the spermatic particles of the Annelides and their development, do not agree with the view above expressed. Here, as elsewhere, I have found them to be the nematophorosed nucleus of the daughter-cells. It is true that with the Lumbricii they present some peculiarities, but these are apparent only. The mulberry-like mass to which they are here found adherent, is composed of the remains of the development, and the spermatic particles which seem to radiate from it in all directions present this appearance because they are then just escaping from the daughter-cells, and the more or less adherence of the membrane of these last to the particles, gives the appearances above mentioned in the note. I have observed the same appearances with some of the Coleopterous insects, where the development occurs unmistakably in special cells. These particles are, according to my own observation, similar like with the Hirudinei, and Lumbricii, but are pin-shaped with some of the Capitibranchiata.-Ed.
With the Nemertini, and Branchiati, the sexes are upon separate individuals, and the genital organs are composed simply of testicles and ovaries.

§ 165.

The structure of the genital organs of the Nemertini is yet quite obscure. The few researches hitherto made only furnish the general result that the sexes are separate.

There are numerous glandular follicles situated laterally in the parenchyma of the body between the skin and the intestinal canal, which are closely aggregated and serially arranged.

With some individuals, these follicles contain eggs, and with others, sperm. They ought, therefore, to be regarded as ovaries and testicles. Each follicle opens separately upon the surface of the body. There are very contradictory statements as to whether these animals have, or have not, copulatory organs.

According to some Naturalists, the worm-like organ, concealed in a canal extending along the back, and which, with both sexes, is often protruded and moved actively about, ought to be regarded as an excitatory organ, although no connection between it and the testicles or ovaries, has as yet been found. According to others, it is a proboscis unconnected with the genital organs. (2)

§ 166.

The disposition of the genital organs of the Hirudinei and Lumbrici, is essentially different.

The first have only two simple genital openings, — one male, the other female, both situated, one after the other, upon the median line of the ven-

1 See Duges, Ann. d. Sc. Nat. XXI. 1830, p. 76, Pl. XI. fig. 5 (Polystemma (Prostomum) armatum); Johnston, Mag. of Zool. I. p. 362, Pl. XVIII. fig. 2, 6, 8, Pl. XVIII. fig. 2 (Nemertes, and Solorinia); Orsted, Entwurf, 1813, loc. cit. p. 25 (Platworm); p. 22, Tat. III. fig. 41 (Tetrasema variicolor); Koiliiker, Verhandl. d. schwed. natur. Versamm. an Chur. p. 91 (Nemertes); and Rothke, Dart, Schrift. loc. cit. p. 98 (Borlasia striata). This last author has not seen the ovaries of the genital organs, Quatrefages (Regne anim. Illust. loc. cit. Pl. XXXIV. fig. 1, n. u.) did not see them with Nemertes Camilla, and Johnston is also silent on this subject. According to Orsted (Entwurf, loc. cit. p. 25, Tat. III. fig. 47, of Notospermum flaviceps) the Nemertini secrete from the whole surface of their body, a gelatinous mucous, which surrounds the eggs, and thus forms an envelope into which they can draw their bodies. Sometime similar to this occurs with the Lumbrici and Hirudinei. See below.

2 The Nemertini being of distinct sexes, this organ can be regarded neither as a penis, nor as an evaginated spermatheca, as Hesekke has done (Isis, 1830, p. 652, Tat. VII. fig. 2). More properly could it be considered, with Orsted (Entwurf, loc. cit. p. 25), as an excitatory organ; although Rothke (Dart, Schrift. loc. cit. p. 100, and Nov. Act. Acad. Nat. Cur. XX. p. 255) regards it as of a tubelike, and Kolliker of a probable nature (Verhandl. d. schwed. loc. cit. p. 99). Other observers agree with Ehrenberg (Symb. phys. loc. cit.) that it is an intestine and an evaginated oesophagus, its orifice being a mouth; but this is undoubtedly erroneous. With Polystemma armatum (Duges, Ann. d. Sc. Nat. loc. cit. p. 76, Pl. XI. fig. 5) Tetrasema variicolor (Orsted, Entwurf, loc. cit. p. 25, Tat. III. fig. 41), and Nemertes (Johnston, Mag. of Zool. I. p. 520, fig. 2; Quatrefages, Regne anim. Illust. loc. cit. Pl. XXXIV. fig. 2; and Kolliker, Verhandl. d. schwed. loc. cit.) there is at the centre of this organ a dart, pointing forward, which is horny, according to Duges, and calcareous, according to Orsted. On each side of this dart, there is a reservoir of many others, smaller and yet imperfect, destined, probably, to replace the former when lost. Duges, Johnston, and Quatrefages, who regard this organ as an intestinal canal, and Kolliker, who considers it prehensile, all regard these darts as a kind of teeth; but Orsted thinks they serve to excite the genital organs. For my part, they involuntarily remind me of the darts of the Helodina. [Additional Note.] — I have now satisfied myself upon living individuals of Tetrasema, that the eggs can escape from the visceral cavity through numerous lateral openings in the wall of the body. I am also satisfied that with the Nemertini, the walls of the digestive canal (the middle body-cavity according to Quatrefages) are not the points of departure of the genital organs, as Quatrefages thinks, and who also would regard as a digestive tube the snout of these animals, an organ which is yet enigmatical. The very detailed figures which this naturalist has given (loc. cit.) of the walls of the digestive canal of these animals, present nothing like an ovari, and show no trace of the presence of germs.
tral surface. The posterior opening connects with a short muscular canal which may be regarded as a reservoir of eggs.

From the base of this reservoir, a narrow spiral canal passes off, and bifurcating into two oviducts, terminates with two round ovaries.\(^1\)

From the anterior opening, a long filiform penis may be protruded, which, when not erected, lies spirally concealed in a bulbous muscular sheath. A Ductus ejaculatorius extending from the seminal vesicles, opens into each side of this sheath. These seminal vesicles are formed each by a kind of continuation of the vas deferens into a varicose tortuous canal, which lies in the midst of a dense cellular tissue. The Vasa deferentia are narrow, and passing backwards along the sides of the body, receive upon their internal surface the short excretory ducts of the live, nine, or twelve pairs of round isolated testicles, which form a double row near the ventral cord.\(^2\)

With many Hirudinei, a portion of the skin is connected with the sexual function. Such is the case with Nephelis, with which numerous cutaneous glands are developed upon the back and belly near the female genital opening. The skin soon has a bloated, transparent appearance, so that the animal appears to have a girdle about its anterior extremity. Before the deposition of the eggs, these glands secrete a substance which hardens in water, and surrounds the body of the animal like a horny belt. This belt is filled with a greater or less quantity of eggs; the animal then withdraws, or slips out from it, while its two extremities are closed up by its own elasticity; but the embryos developed in this egg-capsule are not thereby prevented from making their escape.\(^3\)

The Sanguisugae form cocoons in a similar manner; but they are surrounded with a very thick, spongy substance.\(^4\) The various species of Clepise form sac-like capsules for their eggs, and which they usually carry about with them, attached under their belly, — shielding them with their body at the approach of danger.\(^5\)

\(^1\) See Brandt, Mediz. Zool. II. p. 252, Taf. XXIX. A. fig. 45, 46; Moquin-Tandon, Monogr. loc. cit. p. 50, Taf. IV. Piscicola.\n
\(^2\) See Rayer, Ann. d. Sc. Nat. IV. 1835, p. 247. The Vasa deferentia of the seven pairs with Piscicola are dilated before reaching the two seminal vesicles into two long and very flexuous tubes (Epididymis, according to Leo, loc. cit. 1843, p. 425, Taf. XI. fig. 10). With Piscobela, there are five pairs of these organs ; with Harmopis, eight : and with Aulacostomum, twelve (Moquin-Tandon, Monogr. loc. cit. PI. III. fig. 3; Pl. I. fig. 6. PL II. fig. 10). With Nephelis, the arrangement is different, there being on each side of the posterior part of the body, numerous testicular vesicles united in a botryoidal manner; see Moquin-Tandon, Monogr. loc. cit. PI. III. fig. 4.\n
\(^3\) See Grube, Untersuch. über die Entwicklung d. Clepiseina, 1844, p. 1.

\(^4\) See Brandt, Mediz. Zool. II. p. 252, Taf. XXIX. A. fig. 32-44. The Vasa deferentia of the seven pairs with Piscicola are dilated before reaching the two seminal vesicles into two long and very flexuous tubes (Epididymis, according to Leo, loc. cit. 1843, p. 425, Taf. XI. fig. 10). With Piscobela, there are five pairs of these organs ; with Harmopis, eight : and with Aulacostomum, twelve (Moquin-Tandon, Monogr. loc. cit. PI. III. fig. 3; Pl. I. fig. 6. PL II. fig. 10). With Nephelis, the arrangement is different, there being on each side of the posterior part of the body, numerous testicular vesicles united in a botryoidal manner; see Moquin-Tandon, Monogr. loc. cit. PI. III. fig. 4.\n
The genital organs of the Lumbricini are very difficult of dissection; for often those of both sexes are intimately united together into a common mass. It is certain, however, that the male and female orifices are always in pairs and situated at the anterior extremity of the body, near the ventral median line.\(^1\)

These orifices communicate with more or less numerous glands, sae, and pyriform or cylindrical vesicles.

Their nature as testicles, ovaries or sperm-receptacles, is known only by their contents. As yet it has been possible to trace only very imperfectly their excretory ducts. With some, two of these caecal organs have been observed interspersed in each other. The internal one contained spermatic particles, and should therefore be regarded as a testicle; while the outer one contained at its base, eggs and egg-germs, and ought therefore to be taken for an ovary.\(^2\)

The larger Lumbricini appear to be without copulatory organs, the collar situated back of the genital orifices, taking their place. With many, it is situated chiefly on the back, but terminates on the belly with two long lateral swellings, which, during coition, seize those of the other individual.\(^3\) This collar, moreover, is composed of a mass of glandular follicles, which copiously secrete, during the sexual period, a white, viscous liquid.

It is then very fully developed, but at other periods it is scarcely visible. The belt which is developed near the genital openings of the smaller Lum-

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1. With *Lumbricus terrestris*, the two anterior genital openings are male, and the two posterior, female. These have been figured by Montier (loc. cit. fig. 2), a. c., Leo (De Struct. Lumbr. terrestr. Tab. 1. fig. 2), and by Morren (loc. cit. Tab. III. fig. 2). With Scaenura, and Naia, I have also found these two pairs of genital openings.

2. This invagination of the testicle in the ovary has been distinctly observed by me with *Scaenura variata*, *Naia prodromus*, *Arch. H. Meyer*’s late researches upon the very complicated genital apparatus of *Lumbricini terrestris*, it appears that there are three pairs of seminal vesicles and testicles; these last being intimately joined with as many ovaries (Müller’s Arch. 1844, p. 480, Tab. XIII. fig. 12). It is probable that here the testicles and ovaries are also invaginated, and that the vessels which have usually been taken for testicles are only vesicular seminades; see Morren, loc. cit. p. 173, Tab. VII.—V. and Pronovius, in his Zeitsch. f. Physiol. Vol. x. p. 154, Tab. VII. However, as yet I have been unable to trace to their termination, the excretory ducts of the testicles and ovaries which are invaginated together.

This point is all the more difficult, for, as Dujéz appears to represent (Ann. d. Sc. Nat. XV. 1825, p. 292, Pl. IX. fig. 2, or 1826, Tab. III. Tab. 9, fig. 2), the vas deferens is probably invaginated in the ovary. Many observers have gone so far as to think that the eggs having escaped from the ovary, and fallen into the cavity of the body, pass gradually to its posterior portion, and are there evacuated through invisible openings. On this account, several of them have taken for eggs and embryos, the collections of heavy spicules, and fibres, which are often found in these animals. See above, § 115, note 1; and E. Home, Lect. on Comp. Anat. IV. 1825, Pl. CXLIIX.

I have always been astonished that, at the epoch of procreation with Scaenura, Enurus, and Naia, the two anterior genital openings should communicate with two cæca which contain sperm and long bundles of spermatic particles, but never their cells of development. Dujéz has made a similar observation with his *Naia filiformis* (Ann. d. Sc. Nat. loc. cit. p. 290, Pl. VII. fig. 22), only he does not specify the contents of the organs. Menze, also, has observed these two cæca with *Enurus*, but he hesitatingly regards them as testicles (Friesmann’s Arch. 1845, I. p. 52, Tab. III. fig. 2, aa. fig. 2). Never having seen any connection between these cæca and the testicles behind them, I am disposed to think that the two posterior genital openings of some Lumbricini, are the common orifices of the invaginated testicles and ovaries, while the anterior cæca, which are filled at certain times with sperm, are two ischial *Receptaculum seminis*. During the mutual coition, the sperm will pass from the testicles into these reservoirs, in order to be used during the subsequent deposition of the eggs.

From Hoffmeister’s description (Die 1848 known. Arten aus der Familie der Renzünder, 1848, p. 15) of the copulatory act with *Lumbricini agricola*, it would appear that the sperm remains equally distant from the female organs, being received into special fissa, which correspond perhaps to the *Receptaculum seminis*. *Naia prodromus*, although having a pair of genital openings, has only one testical-ovarian canal, both of which although invaginated, have a very active and independent peristaltic action. They are bifurcated anteriorly. See Gruithuisen (Nov. Act. Acad. nat. Oor. XI. p. 216, Tab. XXXV. fig. 4, 5), who has very correctly perceived the eggs in the bottom of the ovarian sac, but not the nature of the invaginated testicular canal.

3. With *Lumbricini olidus*, the two copulating individuals seize each other so tightly by their collars, that each of these animals completely envelops the other by this organ; see Hoffmeister, in Hiegmann’s Arch. 1843, I. p. 100, and, De ver-"
4 Searuarias, Nais, &c.; see Grütthausen, loc. cit. Tab. XX. &c., fig. 5, b. b.

3 With the large species of Lumbriicus, each co- 
cocoon has from one to six eggs (L. Dyfouri, Ann. d. 
Sc. Nat. XIV. 1828, p. 216, Pl. XII. B. or, Eröreip's 
Notiz. No. 472, 1828, p. 149, fig. 15-16 i; and Hoff 
meister, De vernalis quinnaeum, Tab. I. and Die 
Arten aus der Familie, &c., p. 16, 25, 42). With 
the smaller Lumbriculus, as with Saerurias, Naeax, 
Nais, &c., the cocoons contain nearly always five 
or eight eggs (Duges, loc. cit. XV. Pl. VII. fig. 5, 
Nais). Most of these cocoons have appendages by 
which they are attached to vegetables and other 
body, Hoffmeister (Die Arten aus der Fam. &c. 
p. 42, fig. 9, c) has figured a very remarkable 
husk-shaped cocoon of a new species, Criodrilus 
venes.

1 See Treverianus, Zeitsh. f. Physiol. III. 1827, 
p. 165, Tab. XIII. fig. 17, 18 (Aphrodite); Rathke, 
De Bogyro et Nervide, p. 20, Tab. II. fig. 12. l. 
(Yerecis), and Danzig, Schrifl. loc. cit. p. 66, Tab. V. 
fig. 6, hh. fig. 11, aa. (Amphiprito); Grube; 
Zur Anst. d. Kleverwürmer, p. 16, Tab. 1. fig. 1, 
2, m. (Arenicola), p. 44, Tab. II. fig. 6, y. z. (Ex 
ier); also, Nov. Act. Acad. XX. p. 201, Tab. X. 
fig. 15, 15. m. (Amoynaprane). Rathke's and 
Grube's opinion upon the presence of both male 
and female organs with the same individual is only 
an uncertain supposition, founded upon no histo 
ological examination of the parts. 

2 This condition of the genital glands after the pro 
creative season, is the reason why, as yet, we pos 
sess so few facts as to their structure. Most ob 
servers, among them Rathke and Grube, are 

§ 168. THE ANNELIDES. 

bricini at this period, is of an analogous nature. It is also composed 
of numerous cutaneous glands, closely aggregated, and extending completely 
over many segments of the body. (6) The secretion of this collar is like that 
observed with the Hirudinei, probably for the formation of cocoons. But 
these cocoons differ from those of the Hirudinei in having the place of their 
opening prolonged into a long, narrow neck. (6)

§ 168.

The Branchiata resemble the Arthropoda in their attenuated body, their 
distinct head endowed with organs of sense, the structure of their nervous 
system, and the development of their locomotive organs; but, from the 
simplicity of their locomotive apparatus, and the complete absence of cap 
ulatory organs, they would be carried towards the Zoophytes. 

Here the sexes are separate, and the genital organs of both the Capit 
branchiata, and Dorisbranchiata, appear as simple glandular bodies, ovaries 
or testicles, which project from the ventral surface into the cavity of the 
fasceiuli of the cutaneous muscle. (6) At the sexual period, they are 
filled with eggs, or spermatic particles, although at other times they can 
scarcely be seen. (6)

Neither the testicles nor the ovaries have excretory ducts which open 
upon the surface of the body. The sperm and eggs escape into the cavity 
of the body, which, during this period is thereby filled throughout. (6)

It is possible that the scarcely visible orifices so be to be concealed be 
of the opinion that the Branchiata, like the Lambri 
cini, are hermaphrodites. But Quatreages, from 
his knowledge of the development of the spermatic 
particles, has recognized separate sexes with the 
most different species, thus: Terebella, Sabella, 
Aricinella, Nepthys, Syllis, Glycera, Eunice, 
Sigalion, Physidoe, Nereis, and Aphrodite; 
see Comp. Rend. XVII. 1843, p. 423. But before 
this, Steinmann has concluded that the sexes were 
separate with Arenicola, from a difference in the 
contents of the cavity of the bodies of different 
individuals (Muller's Arch. 1840, p. 375). The 
 glands at the cephalic extremity of the Branchiata 
which live in cases, and which Grube has regarded as 
male genital organs, are certainly not such, for 
they occur with both sexes, and do not change in size 
during the procreative season. (See § 161, note 4.)

3 According to Quatreages (Comp. rend. 
XVII. 1843, loc. cit.), the parent sperm-cells 
leave the testicle before the formation of the 
spermatic particles, which occurs in the cavity of 
the body. This is confirmed with Arenicola, by 
Steinmann (Muller's Arch. 1840, loc. cit.). Ac 
cording to Krohn (Wiesmann's Arch. 1846, I. p. 
182), the eggs and the spermatic particles, with 
Al 
cispa, are developed free in the visceral cavity, 
without the intervention of special organs, ovaries 
and testes. Frey and Leuckart (Beitr. &c. p. 
88) think they have observed the same fact with 
Nereis, Syllis, Phylidoces, Avinis, Amoynaprane, 
Ephesia, Hermitia, Verruca, Fabriceia, and 
Spiorbis; they speak of the presence of ovar 
ies and testicles in certain Annelides (Aphrodite, 
Arenicola) as the exception.

* § 168, note 2. According to Quatreages 
(Ann. d. Sc. Nat. X. 1845, p. 46) the sexes are sep 
arate with the Hermelia. Both the testicle and the 
ovo consist of a delicate arenaceous tissue adherent to 
the inferior internal surface of the general cavity 
of the body. These genital organs are evidently tem 
perary, for they are not found in many individuals, 
having, probably, quite disappeared from atrophy 
after the procreative period. This fact should be 
remembered in the study of the genitalia of other 
Annelides. — En. 

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between the feet of many Branchiati, serve for the escape of the sperm and eggs.\textsuperscript{4} With others, the cavity of the body opens outwardly, probably by a loss of the last segment, especially with those which are viviparous.\textsuperscript{5}

The water is undoubtedly the medium of fecundation, and receives the sperm from the males, probably through orifices like those which serve for the escape of eggs with the female.

With the viviparous Branchiati, water filled with sperm can enter the body and fecundate the eggs through these same openings.

\section*{§ 169.}

The development of the Annelides as far as yet known, occurs after two different types; but it always commences with a complete segmentation of the vitellus.

I. With the Hirudinei, after the vitellus has divided into many large cells, a central one becomes distinguished from the others by its still further division; this becomes the digestive tube. The others, still dividing, form a primitive embryonic part in which appears the future ventral and nervous portion.

The embryo is at first spherical, and ultimately is covered with a delicate ciliary epithelium. A kind of sucker is then developed upon a certain point of its surface; this connects with the stomach, and through it is received, for food, the albumen surrounding the embryo. It then gradually lengthens, and, losing its ciliary epithelium before the escape from the egg, a sucker appears upon the posterior extremity, and it finally becomes fully developed without a Metamorphosis.\textsuperscript{5}

II. With the Branchiati, there is a complete metamorphosis. The segmentation of the vitellus is uniform throughout, and this last is finally changed into a round embryo — which, escaping from the egg, swims freely about like an Infusorium, by means of the ciliated epithelium which covers its whole body. The embryo then lengthens, and the epithelium disappears

\textsuperscript{4} According to \textit{Mitar Edwartz} observations upon several Capitibranchiati, as \textit{Teredoidea, S cere-}

puta, \textit{Prostula}, &c., the eggs are glued together in masses by an albuminous substance, and attached to the stems of the anterior border of their cases; see \textit{Ann. d. d. Nat.} 1843, p. 148, 101, Pl. V, fig. 1, Pl. VII, fig. 25, Pl. IX, fig. 42. With \textit{Polymor-}

phus, \textit{cirrata}, on the other hand, masses of eggs are attached and borne about on the scales of their body; see \textit{Sars}, in \textit{Wiegmann's Arch.} 1845, L p. 13, Taf. I, fig. 12. With the females of \textit{Eunogene}

r and \textit{Cystosacris}, the eggs are situated in longitudinal rows upon the ventral surface; see \textit{Orsted}, in \textit{Wiegmann's Arch.} 1845, p. 21, Taf. II, fig. 4, and \textit{Kailiker}, in an as yet unpublished memoir for the Helvetic Society, titled: \textit{Einige Worte zur Entwicklungsgeschichte von Enumm}, von \textit{H. Koch} in \textit{Friss}, mit einem Nachwort von \textit{Kailiker}.

\textsuperscript{5} According to an old manuscript in the possession of \textit{Ilia}.

\textsuperscript{5} According to my friend \textit{H. Koch} of Trieste (in the MS. just indicated), the eggs of a species allied to \textit{Eunum gauges} are developed in the cavity of the female body, whence the young escape through a rupture of its posterior extremity.


lis vulgaris, in \textit{Potter's} neues Not. No. 307, 1846, p. 228. The old observations of \textit{E. H. We}

\textit{ber} (\textit{Merkels Arch.} 1826, p. 366, Taf. A. X. X., and \textit{R. Wagner} (Kis, 1832, p. 398, Taf. IV.) agree very well with those of \textit{Filippi}.

As yet, we possess nothing upon the development of Amphipoda, whose young, as is known, like those of the Hirudinei, leave their cocoons without undergoing any metamorphosis.


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As yet, we possess nothing upon the development of Amphipoda, whose young, as is known, like those of the Hirudinei, leave their cocoons without undergoing any metamorphosis.
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except upon the belt-like parts of the two extremities. The future anterior extremity is directed in front during the motions of the animal, and eyes appear upon it; while the other extremity is gradually divided into segments upon which bristles and feet appear.\

While the embryos are thus acquiring the adult form, there appear upon the cephalic extremity and upon the sides of the body, tentacles, cirri, and branchiae, of forms which vary according to families, genera and species. The development of the digestive and circulatory organs occurs also with equal pace.\

\[2\] See Loës in Wiegmann’s Arch. 1842, I. p. 302, Taf. VII. (Nereis); Saraz, Ibid. 1845, I. p. 12, Taf. I. fig. 1-21 (Polydora); Orsted, Ibid. p. 20. Taf. II. (Exozone); and Milne Edwards, Ann. d. Sc. Nat. III. 1845, p. 145, Pl. V.—IX., or, Froidefpe’s neue Not. No. 721, p. 257 (Terebella, Protula, and Nereis). Kohleri (in MS. already cited) has also observed the development of an Exzone, and of a Cytonereis, an allied genus. Here the embryo is not formed through a complete and uniform segmentation of the vitellus, but, as with the Hirudines, the formation is preceded by an irregular division of that portion to be the ventral and nervous parts. He, at the same time, calls the attention to a figure of Milne Edwards, representing the development of Protula, from which it would appear that other Branchiata also are developed like the Hirudine; see Ann. d. Sc. Nat. loc. cit. Pl. IX. fig. 47.  

\[3\] One ought therefore to be careful about forming distinct genera from these larval Branchiata. Thus, Sabellina braachrycea, described by Du Jardin (Ann. d. Sc. Nat. XI. 1839, p. 291, Pl. VII. fig. 6), is only a larval Terebella, as will be seen by referring to Milne Edwards’ figures of the development of Terebella nebulosa (Ann. d. Sc. Nat. loc. cit. Pl. VII. fig. 24, 25). Anisometes lutens, of Templetton (Transact. Zool. Soc. II. 1842, p. 27. Pl. XV. fig. 9-14), is perhaps only a young Serpula. The absence of branchiae and blood-vessels which Quatrefages has noticed with many small Branchiata of which he has made new genera (as Apheline, and Dougria, etc.), would lead one to suspect that they are only larvae; see Ann. d. Sc. Nat. I. 1844, p. 18, or Froidefpe’s neue Not. No. 726, p. 341. H. Koch (see above, § 169, note 5) has lately observed that the young individuals found in the body of Eunice are identical with the Lambrineres of De Blainville. The new animal described by Müller and Busch (Müller’s Arch. 1846, p. 104, Taf. V. fig. 3-5, and 1847, p. 187, Taf. VIII. fig. 1-3) under the name of Mesanocha sexuulata, appears likewise to be only a young larva of an Anellid.\

\[4\] [§ 169, note 2.] For the embryology of Polydora, see Desor, loc. cit. p. 12. It agrees closely with that of Nemertes; see also Max Muller, in Müller’s Arch. 1851, p. 323. — Ed.\

BOOK NINTH.

ACEPHA L A.

CLASSIFICATION.

§ 170.

The Acephala are principally characterized in having a headless body, and a very large mantle, which so envelops the body, that there is a spacious and more or less closed cavity in which the oral and anal orifices are often entirely concealed.

Their body is either wholly asymmetrical, or divided into a right and a left side. In this last case, the organs, excepting the digestive canal, are in pairs; and the two sides are perfectly symmetrical, or one is developed at the expense of the other. All Acephala are aquatic; many are permanently attached during life; others creep about, and a few only can swim freely. Copulatory organs are wanting throughout.

ORDER I. TUNICATA.

Body wholly asymmetrical and so enclosed in the mantle, that there are only two narrow openings.

Family: Ascidiae.

Genera: A. Compositae.
Didemnum, Diazona, Aplidium, Botryllus, Botrylloides, Leptoclinum, Eucloemium, Synoecium, Polyclinum, Sigillina, Perophora, Pyrosoma.
B. Simplices.
Clavelina, Phallusia, Rhopalaea, Boltenia, Cynthia, Chelysoma.

Family: Salpinæ.
Genus: Salpa.

ORDER II. BRACHIOPODA.

Animals which are symmetrical and bivalved, and whose widely-open mantle encloses two fringed, arm-like, protractile tentacles.
Genera: Orbicula, Terebratula, Lingula.

ORDER III. LAMELLIBRANCHIA.

Animals which are symmetrical and bivalved, and whose more or less closed mantle encloses two pairs of lamelliform tentacles and branchiae.

SUB-ORDER I. MONOMYA.

Family: Ostracea.
Genera: Ostrea, Anomia.

Family: Pectinea.
Genera: Pecten, Spondylus, Lima.

Family: Malleacea.
Genera: Malleus, Perna, Crenatula.

SUB-ORDER II. DIMYA.

Family: Aviculacea.
Genera: Avicula, Meleagrina, Pinna.

Family: Arcacea.
Genera: Arca, Pectunculus, Trigonia, Nucula.

Family: Naiades.
Genera: Anodonta, Unio.

Family: Mytilacea.
Genera: Mytilus, Modiola, Lithodomus, Tichogonia.

Family: Chamacea.
Genera: Chama, Isocardia.

Family: Cardiacea.

Family: Pyloridae.
Genera: Mya, Solen, Solenomya, Panopaea.

SUB-ORDER III. INCLUSA.

Family: Teredina.
Genera: Pholas, Teredo.
Family: Aspergillina.
Genera: Aspergillum, Claragella.

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CHAPTER I.

CUTANEOUS SYSTEM.

§ 171.

The body of the Acephala is enveloped in a special mantle, which, with the Tunicata, is composed of a leathery, cartilaginous, or gelatinous substance, scarcely at all irritable. But with the Lamellibranchia, and Brachiopoda, it is composed of a contractile, fleshy membrane. With the Tunicata, it com-

1 The mantle is leathery with Cynthias, cartilaginous and hard with Phialusia, cartilaginous and soft with Salpa, and gelatinous with Clavelina, Dicranona, Aplidium, Botryllus, and Pyrosoma.
pletely surrounds the body and has only an oral and anal opening; \(^2\) and with the compound species, it is continuous with the common substance which contains the individuals and binds them into more or less regular groups, and is, therefore, analogous to a coralium. With the Lamellibranchia, and Brachiopoda, it is more or less open, or even may be wholly divided into halves; \(^3\) it has here the property, especially upon its borders, of secreting calcareous matter for the formation of the shell.

§ 172.

With the Tunicata, the mantle is remarkable both for its histological structure, and its chemical composition. Recent investigations have shown that, with the Ascidiae and Salpinae, it is composed of Cellulose and therefore of a non-azotized substance.\(^1\)

Its anatomical structure is quite complicated. Usually it can easily be separated into two or three layers, the internal one of which is composed, in some species, of a laminated epithelium formed of a single layer of polygonal nucleated cells.\(^3\)

Its principal mass in both the compound and simple forms of this order, is formed of a single, or a double confluent layer of a homogeneous transparent substance, through which are scattered granules, nuclei, groups of pigment molecules, cells, fibres, and crystals of carbonate of lime,—all varying according to genera and species, and often differently arranged in one and the same species.\(^2\) But in each species, they are variously arranged in the inner portion of this mantle-substance.\(^4\) In some species

2 These openings are properly only simple ori-fices of the cavity of the body, and correspond to the respiratory tubes of certain Lamellibranchia; see below, § 150.

3 With Mya, Panopea, Phoebus, Teredo, As-pergilum, the mantle is almost entirely closed, but it has two long fissures at each extremity with Solen, Cyclas, Tellina, Mytilus, Litho-domus and others; with the Ostracae, Pedicellaria, Anadonta, Nautilus, and Brachiopoda, it is entirely open.

4 This important fact was first stated by Carl Schmidt (Gart. Vergleich, Physiol. d. Wirbellosen Thiere. 1846, p. 61), with Cynthia mamillosa, and has subsequently been confirmed by Löwig and Kölliker, after the most careful investigations upon the entire order of Tunicata (Comp. rend. 1846, p. 38). These two authors found this non-azotized substance, particularly in the different species of Phallusia, Cynthis, Clavelina, Didemnum, Brotulites, Didemnum, Apidium, Salpa, and Pyrosoma; but not with the other Moluscs, nor with the Anellides, the Helminthes, the Echinoderms, the Acapephae, and the Polypla. It is certainly wanting in the true Infusoria, for Fussilula solina, which Carl Schmidt cites as belonging to this order and as containing cellulose, is evidently a vegetable. Löwig and Kölliker justly fear, moreover, that this discovery will be quickly seized by those who deny that there is any limit between the animal and vegetable kingdom (see loc. cit. p. 8). They seek, therefore, to oppose this view by insisting upon the circumstance that this cellulose is never found in a pure state in the mantle of the Tunicata, but always combined with other substances, and that, moreover, no animal has as yet been found entirely composed of this substance.

3 This basement substance is homogeneous, and has the same chemical properties as cellulose.

5 Kölliker has made very detailed investigations upon the structure of this mantle. He has kindly allowed me to communicate his results, and authorized me to make use of them without waiting for the publication of his work in common with Löwig (Ueber das Vorkommen von Holzfaser im Thiereich). According to them, the middle layer of the mantle of Phallusia mammillata, Clavelina lepoldformis, and Apidium gibbosulum, contains numerous nuclei and star-like crystals lodged in a transparent structureless substance. But the external layer of this organ is filled with very large round cells with very thin walls, containing no nucleus, but filled with a transparent liquid. With Clavelina lepoldformis, the peduncle and branches of the whole mantle are so crowded with non-nucleated cells, some round and others elongated, that the basement-substance is apparently absent. It has therefore quite the aspect of a vegetable tissue. With Apidium gibbosulum, and Brotulites violaceus, the cells of the external layer contain carbonate of lime which ultimately so increases that it gives them a petrified aspect. With Didemnum candidum, these petrified cells have calcareous rays and are so numerous that the whole mass of this compound Ascidian appears filled with white star-like corpuscles.

According to Milne Edwards, this is true also of Lepocidium maculosum (Observ. sur les Ascidies comporées, p. 51, Pl. VIII, fig. 2). With Diazona violaceum, Pyrosoma gigan-teum, Brotulites polycyclus, Salpa maxima, and bicaudata, the mantle is without these elegant cells, and in the basement-substance are found only granules and nuclei, and with Diazona, in addition, pigment-granules, and crystalline points, or calcareous concretions.
These last are spherical or star-like, with Salpa maxima, and dendritic with Salpa bicornis; with these species they are not soluble in hydrochloric acid, and are therefore probably composed of silk. In the mantle of Batrachia, there are, in certain places, peculiar flexuous fibres running in all directions. If these are treated with potassa they will appear evidently composed of cellulose.

According to Kölliker, the structure of the mantle of Cynthia papulata is still more complicated. Its middle layer is composed of longitudinal and circular flexuous non-azotized fibres. Between these lie granules, nuclei, crystals and cells; these cells are naked, and contain, sometimes pigment granules, and sometimes daughter-cells which give them the appearance of those of cartilage.

Kölliker was unable to determine the structure of the third and external layer which is horny, for he had at his disposal only alcoholic specimens of this Cynthia. He saw however that it is united with the middle layer to form the spines which project from the surface of the skin.

In the mantle of Cynthia pomaria, the longitudinal fibres predominate, and between them lie crystals, round pigment-cells, and other cells which are peculiar and filled with yellow corpuscles; and finally, a third variety arising from the transformation of the pigment-cells, whose walls are gradually thickened and ultimately split up into filaments, forming concentric layers around the cell-cavity. When subjected to potassa, these cell-membranes are decomposed, like the principal fibres, into an insoluble, non-azotized substance, while all the other elements of the mantle entirely disappear under the action of this agent.

The researches of Kölliker and Löning upon the mantle of the Tunicata, have been recently published in the Ann. d. Sc. Nat. V. 1840, p. 153, Pl. V.-VII.

Blood-vessels are found in the mantle of various Phallusias; they are spread out in a reticulated manner, especially in the external layer. See Cuvier, Méms. sur les Ascidies, &c., p. 10, Pl. III. fig. 1 (Phallusia mamillaria); Scatonyx, Méms. &c. p. 102, Pl. IX. fig. 1. B. (Phallusia sulcata); and Distle Chirurg. Descrizions e notizie degli animali invertebrati della Sicilia eterno Tom. III. 1841, p. 33, Tavr. LXXXIV. fig. 2 (Phallusia monacalis).

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of this order, the mantle receives, moreover, numerous blood-vessels, or ramified prolongations of the body of the animal.
§ 173.

With the Bivalvia, the mantle exhibits (especially near its free borders), contractile motions upon the slightest touch. These are due to numerous muscular fibres which traverse in every direction its granular parenchyma, but are most abundant in the borders. It contains here, moreover, nerves, blood and achiroylic vessels, and in some species, even genital organs. The borders of the mantle of the Lamellibranchia are often provided with very sensitive contractile tentacles;\(^1\) these are rarely wanting around the anal opening,—an orifice which serves also for the respiration.\(^2\) In many, this anal opening is divided by a septum into a round, superior and inferior orifice.\(^3\) The borders of these two orifices are often prolonged each into a longer or shorter fleshy tube (Sipho). These two tubes, which are often blended together, project considerably out beyond the mantle and shell, but usually can be wholly withdrawn.\(^4\)

With the Brachiopoda, the border of the mantle has, instead of retractile tentacles,—hyaline, radiating filaments, which are hollow and deeply inserted in the substance of the mantle.\(^5\)

With the Lamellibranchia, and Brachiopoda, the internal surface of the mantle is covered with ciliated epithelium, which extends also upon the abdomen, foot, oral tentacles, and brachial lamellae.

This epithelium is of great importance, since it constantly directs currents of water into the mantle, and thereby food is brought to the mouth, fresh water to the branchiae, the eggs and sperm are carried away from the genital openings, and the faeces are rejected outwardly. The existence of this epithelium makes it clear how these animals can continue to live when buried in wood or stone.

§ 174.

The mantle of the Bivalvia is covered by two shells, whose infinite variety of form serves for their zoological classification into genera and species. These shells are composed for the most part of carbonate of lime so closely

With many of the compound Ascidiae, the body sends fleshy, ramified prolongations into the mantle. These have been regarded as blood-vessels by Sauvage (Mem. Soc. p. 47; Dizeaux and Botryl-\(\text{\texttildetilde}}\)us), and Dela Chapie (Dessarg. Soc. 111. p. 53, Tav. LXXIII. fig. 13, 19 (Popeclma viride)); but Miller Edwards (loc. cit. p. 41, Pl. VII. fig. 1, 1b. 1c. 5a—5d.) has regarded them with Botryllus rotifera, and Didemnum gelatinum, as hollow prolongations,—a view entirely assumed to be Kaf-\(\text{\texttildetilde}}\)kera.

1 With Avicula, Aonina, Pecten, and Spon-\(\text{\texttildetilde}}\)dus, there are two or three rows of cylindrical tentacles along the border of the mantle; with Lima, these tentacles are highly developed, and are situated upon the convex edge of the fold of the mantle. With Mytilus edulis, they are peculiar, being flattened and digitiform.

2 With the Naiades (Unio and Anodonta), there are no tentacles around the anal fissure, while the principal mantle-orifice which is separated from this last by only a narrow isthmus, has them quite numerously upon its borders; see Pfeiffer, Nat-\(\text{\texttildetilde}}\)ur, deutsch, Fig. 39. and Fossman; Alth. II. Taf. I. fig. 2, 5, 9, p. 6. These Naiades have also a third fissure, which is dorsal and situated quite distant from the anal one; it was first pointed out by Dallmayer. I am yet unsettled as to its nature. See Pfeiffer, loc. cit. Taf. I. fig. 5, 1.

3 Isocardia, Tridacna, and Chama.

4 With Peaumoa, Pellina, and Venus, the sipho is double and very protracile. With Cy-\(\text{\texttildetilde}}\)clus, and Teredo, the two respiratory tubes are more or less blended together at their base; and they are united so as to appear as a single organ with Mostra, Mga, Psychogon, Solen, Pholus, Lat-\(\text{\texttildetilde}}\)raris, Ciavagella, and Aspergilum.

In these two last genera, the mantle is prolonged directly into a sipho without any appreciable line of separation. It is almost entirely closed, and beside the sipho and the narrow anterior opening, there is in the middle of its ventral border, a very small aperture, whose nature is yet with me doubtful; see Kappell and Leuckart, Neue wiech-\(\text{\texttildetilde}}\)lose Tiere der rothen Meeres, p. 41, Taf. XII. fig. 4, a, and Oecua, On the Anatomy of Ciavag-\(\text{\texttildetilde}}\)ella, in the Transact. of the Zool. Soc. London, L. p. 270, Pl. XXX. fig. 13, 14, or the Isis, 1836, p. 448, 1837, Taf. II. fig. 15, 14.

These filaments appear to be composed of a horny substance. They are smooth and very small with Tecesta, and very long and jointed with Orbicula and Lingula.

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blended in a homogeneous organic base, that this last is not apparent except by the aid of acids. In a few only, does this organic base predominate over the calcareous matter.\(^1\)

The intimate structure of shells is quite varied,\(^2\) but nearly always an external fibrous, and an internal lamellated layer may be distinguished by aid of a simple lens. The external layer appears to have a crystalline texture, being composed of thickly-set, calcareous prisms, attached perpendicularly or obliquely upon the internal layer. These prisms, however, are not the result of a crystallization, but, as is shown from their development,\(^3\) are only cells filled with lime, and if dissolved in acid, delicate prismatic cells remain as the organic base. The internal layer is made up of numerous superposed, non-cellular lamellae composed of the organic base, and arranged intricately in various ways. To the plicae thus formed, and between which the carbonate of lime is deposited, is due the pearly aspect of this internal layer. The relative thickness of these layers varies, sometimes one, and sometimes the other, being the greater.\(^4\) The external layer is undoubtedly secreted by the borders of the mantle, while the internal is formed by a secretion of its external surface.

The growth of the shell is not continuous, but occurs only at certain periods of the year; hence the formation of concentric lines and furrows upon its surface, analogous to the yearly rings of trees.

The external layer is often colored, either uniformly throughout, or only in spots; while the internal one rarely contains any pigment. By examining the cicatrized wounds which these animals accidentally present, it will appear plain that this pigment is secreted by the borders of the mantle. For, if these wounds are situated at a distance from these borders, the shell is never filled except by a layer of colorless matter.\(^5\)

In the shells of some Bivalvia there are, moreover, special, narrow canals, which are either simple and traverse the shell obliquely from within outwards, or branched in a reticulated manner throughout its whole extent.\(^6\)

The shells are not attached to the animal except by muscular insertions along their borders, and by an epidermis belonging to the borders of the mantle. This epidermis, composed of a horny, yellowish-brown substance, stretches from the borders of the shell over its whole external surface,\(^7\) and

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\(^1\) The shells of *Lingula* contain very little lime, and there is even still less in the flexible valves of *Orbicularia*.


\(^3\) Mya *avenaria* forms an exception to this; the teeth of its shell contains true prismatic crystals bound together in a star-like manner; see *Carpenter*, Annals of Nat. Hist. loc. cit. Pl. XIV. fig. 8.

\(^4\) These two layers, of which the outer one quite resembles the enamel of the tooth, are very distinctly seen with *Malleus*, *Perna*, *Crenatula*, *Avicula*, *Melisarina*, *Pinnu*, *Anodonta*, *Unio*, &c. With *Ostre*, and *Chame*, they alternate with each other several times. In many *Pectinea*, and *Cardineca*, and with *Anomia*, the fibrous layer appears to be wholly absent.

\(^5\) The formation of pearl occurs only upon the inner surface of the mantle. It has, therefore, the same lamellated structure and iridescent property, as the natural layer of shells.

\(^6\) With *Terebratula*, these canals are quite distinct—occupying the whole thickness of the shell. I have observed the same arrangement with *Cyclina*, white with *Lingula*, they are confined to the internal layer. By direct light they appear black. I am yet uncertain whether this color is due to their extreme tenacity, or to calcareous matter in their interior. If the first, they would be comparable to the canaliculi of the dentine of teeth; but if the second, to the corporacles of bone. *Carpenter* (Annals of Nat. Hist. loc. cit. p. 384, Pl. XIII. fig. 5), has observed that in the shells of *Lima rubra*, these canals are divided and form a kind of net-work.

\(^7\) See *Mytilus*, *Anodonta*, *Unio*, *Solen*, *Lutra*ria and *Mya*.

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* [§ 174, note 2.] For the complete labors of *Carpenter* in this direction, see *Cyclop. Anat.* and
in some species covers even the whole of the siphon.\textsuperscript{6} Very often, however, this epidermis is worn away upon old portions of the shell, which is quite striking with those which have lamelliform or pilous prolongations around the borders of the shell.\textsuperscript{9}

The two shells are joined together partly by a hinge (Cardo), and partly by an elastic tissue (Ligamentum).\textsuperscript{10} This last, either external or internal, is antagonistic to the adductor muscles of the shell. It is composed of elastic fibres, the internal of which, when the shell is closed, are compressed between the borders of the hinge, while those which are external are lengthened out. In both cases, their natural action is to open the two shells.\textsuperscript{11}

\section*{CHAPTER II.}

MUSCULAR SYSTEM AND ORGANS OF LOCOMOTION.

\section*{§ 176.}

The muscles of the Acephala are composed of simple, smooth fibres.
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But *Salpa* presents a remarkable exception to this, for here the fibres are striated. 1

With the Tunicata, the muscular system is most simple, being limited to a subcutaneous layer, which, with the Ascidiae, envelops like a sac the body of each individual, and is attached to the skin only at the two openings of the cavity of the body. It is formed of numerous circular and longitudinal interlaced muscles, among which there are, here and there, oblique fasciculi. 2

With *Salpa*, this cutaneous muscle consists only of a few isolated bands bound together by a thin, homogeneous membrane. These bands, which vary much in number, distance apart, and direction, surround the cavity of the body, usually in a belt-like manner. They are sometimes straight, sometimes curved, and their extremities never meet upon the ventral surface so as to form a complete belt, but terminate loosely, or are blended by anastomoses with adjoining bands. Around the two openings of the body, they form real sphincters. 3

By means of this muscle, the Tunicata can enlarge or diminish the cavity of the body, and thus cause the necessary renewal of water for nutrition and respiration, beside ejecting the faeces and products of generation. The *Salpa*, by rhythmical contractions of their body (its anterior superior opening, being closed by a membranous valve), eject water through its posterior opening, and thus are propelled along.

§ 177.

With the Bivalvia, the muscular system is much more complicated. Not only are muscular fibres scattered through nearly the whole body, but in certain points, they are so aggregated as to form distinct isolated muscles. The largest of these muscles are the Adductores of the valves. With the Lamellibranchia, these consist of a single or a double mass of thickly-set, parallel fibres, the ends of which are inserted at opposite points of the two valves. Those species which have two of these muscles are called Dimya; here one of these muscles is anterior, and the other, larger, posterior. With the Monomya, there is one muscle alone; this is large and situated near the centre of the valves.

With Brachiopoda, these muscles are more complicated, there being four pairs. Part of these, only, are doubly inserted to the valves, 4 while the rest, which arise from one of the valves, are inserted upon the peduncle.

1 See Erschricht, Over Salperne, &c., p. 64, Tab. III. fig. 16. These striæ are due to a zig-zag pil- culation, as I have satisfied myself from a specimen of *Salpa zonaria* preserved in alcohol. Will has observed the same in the muscles of other invertebrates (Muller's Arch. 1843, p. 359). The muscu- lar fibres of *Salpa* are bound together in prim- itive ribbon-like fasciculi which are pilcated during contraction like the frill of a shirt; this is easily seen when one of these fasciculi is observed in an edgewise position.

2 See Sars, *Mém. &c. Pl. V.*, fig. 1, 2 (Bol- tania and Cynthia); *Delte Cherie, Descrip. &c.*, III. p. 21, Tab. XXXIV. fig. 3, 5 (Phallusia); and the Catal. of the physiol. Series, &c., I. Pl. V. (Phallusia).

3 *Salpa cordiformis* and *zonaria* have from five to seven isolated and equi-distant muscular girdles; see Erschricht, loc. cit. Tab. I. III.

4 *Salpa cylindrica* has ten or eleven of these gir- dles, the anterior of which converge upon the back and are curved from before backwards; see Courrier, *Mém. sur les Thalles. loc. cit. fig. 5; and Sars, *Mém. loc. cit. Pl. XXIV. fig. 1*. With *Salpa mucronata* and *axilina*, these girdles are blended together upon the back; see Meyen, *Uber die Salpen, loc. cit. Tab. XXVIII. fig. 5, Tab. XXIX. fig. 2. *Salpa pininata* (crinata) is remarkable for having numerous anastomoses uniting the girdles upon the sides of the body and presenting a trellia-like aspect; see Chamisso, *De Salpa*, fig. 1, 2, G. II., and Courrier, *loc. cit. fig. 1, 2.

5 Several of these muscles do not always arise directly from the shell, but from the visceral sac; so that here their action is not solely for displacing the viscera, but also for the movement of the valves, to which this sac is attached.
As the points of the insertion of these muscles do not always correspond with the two valves, their direction is often oblique, or, they sometimes even cross each other. *Orbicula* and *Lingula*, which want both the ligament and hinge, have this disposition of the adductors which terminate usually by a delicate tendon, and the contraction of either of these muscles alone, produces the lateral movements of their valves.

The spirally-pointed tentacles of the Brachiopoda are moved by a particular apparatus. The fringes of these organs are inserted upon a cartilaginous tubular prolongation which tapers to a point. This is closed at both extremities and contains a liquid, which, by the contractions of the circular muscular fibres, is propelled from the base to the extremity, thereby unrolling the spiral turns. These tentacles here certainly take the place of the elastic ligament of the bivalves, for their extension probably tends to slightly open the valves.

With the Lamellibranchia, the tentacles which are not rolled, are arranged quite differently. Like their branchiae, they are scarcely at all irritable,—this being due to the fewness of their muscular fibres. But in the mantle these fibres are very abundant, and especially near their free borders. This is true also of the Siphon, in which both longitudinal and circular fibres can be easily seen; here, two very distinct flattened muscles arise from the base of the siphon and are inserted upon the two valves, external to the posterior adductor muscle: these serve as a Retractor siphonis.

**§ 178.**

Very many of the Lamellibranchia have a highly-developed organ of locomotion,—the foot. This is a muscular prolongation from the ventral surface, which passes obliquely forward to be inserted upon the internal surface of the back of the shell, by four, rarely more, tendinous cords.

These cords surround the abdominal viscera, and becoming gradually thicker and more muscular, finally blend with numerous, interlaced muscular fasciculi which compose the foot. This last varies considerably as to its size and form, and can be protruded a long way out through the open shells, but may also be wholly withdrawn.

2 *Lingula* forms an exception. Here the principal adductor is a short, solid muscle, which stretches straight across from one shell to the other, at their posterior extremity.

3 This muscular apparatus has been particularly described and figured by Owen, and Vogt (loc. cit.) with *Terebratula*, *Oribacula*, and *Lingula.* With the *Terebratula*, two pairs of muscles arise from each valve. The two anterior ones arising from the imperfect valve, are the longer, and have their origin back of its centre. After the crossing of their delicate tendons, they pass through the opening of the valve and terminate in the peduncle, together with the two posterior ones which are short and fleshy, and which arise at the base of the hinge. Of those of the perforated valve, the two posterior ones only pass to the peduncle—the two anterior being attached to the base of the other valve. With *Oribacula*, there are two posterior, and two anterior fleshy muscles, all of which pass obliquely from one valve to the other, while the anterior ones sometimes send off fibres to the short peduncle. In the space circumscribed by these four muscles, lie four others, which are small and interlaced, and extend from the visceral sac to the valves. With *Lingula*, there are, beside the principal adductor, four pairs of interlaced muscles, which pass obliquely through the centre of the cavity of the valves, and are attached by their two ends to the visceral sac.

4 Owen, loc. cit.; and Vogt, Annt. 4. *Lingula*, p. 8, Tab. 11, fig. 16-18.

1 The foot is absent, particularly with those mollusks which are fixed to rocks and other solid bodies, by a calcareous cement.

2 Usually one pair of these delicate cords passes above, and another below, and are inserted upon the valves, quite near the four points of insertion of the two adductor muscles. This is so with *Anodonta*, *Unio*, *Cardium*, &c. With *Ic Innocens*, I have found a third pair of cords inserted upon the posterior extremity of the summits of the shell. These serve not only as *Retractores* of the foot, but when this last is fixed to some point, draw the animal towards it.

3 The laterally-compressed foot of *Anodonta*, and *Unio*, arises, by a large base, from the abdomen, and has cartilaginous borders. That of *Pectunculus* and *Venus*, is quite similar, but its free border is hollowed by a frown, and is therefore bi-carinated.
Most of these animals use this organ to dig in the sand, or to creep along on soft surfaces. For this purpose, they reach it out in front, and then by alternate contractions and elongations, drag their body after it. Some species can in this way glide freely along the Gasteropoda, or even seize hold of aquatic plants. Sometimes this foot is truncate and hollow at its extremity, and probably, therefore, acts like a sucker.

§ 179.

With many of the Lamellibranchia, the foot appears imperfectly developed, and has a secretory organ of the Byssus, a part by which these animals are attached to wood, stone, and other bodies. In this case the foot is a delicate, protractile, tongue-like body, capable of a stiffness sufficient for creeping, but used chiefly as a feeler to find the points of attachment by the byssus. It always points towards the oral extremity, and upon its inferior surface there is a longitudinal furrow which has a cavity at its base. The walls of this furrow and cavity secrete the byssus. From their glandular aspect, they differ much from the rest of the organ, which is formed of numerous interlaced muscular fibres.

The bottom of this cavity from which the furrow arises, is regularly divided by numerous delicate, parallel lamellae, from which arises the compact root of the byssus. This byssus is, therefore, inserted into the base of the cavity as are our finger-nails into their matrix. Its base has a fibrous, or lamellated structure, and passes into a longer or shorter trunk composed of numerous cylindrical, or flattened filaments, whose extremities are sometimes discord.

§ 180.

Many Bivalvia, which are likewise wanting in locomotive organs, and have, moreover, no organs of the byssus, attach themselves to bodies in another and peculiar way. Thus, with Anomia, one of the valves is marked by a deep fissure, across which, like a short peduncle, a portion of the ad-
ductor muscle of the other valve passes, in order to be attached to foreign bodies by its smooth, calcareous extremity.

With the Brachiopoda, there is a real peduncle which constantly projects through an opening near the hinge. It is a soft tendinous or muscular tube, which is, perhaps, only a prolongation of the mantle.

CHAPTER III.

NERVOUS SYSTEM.

§ 181.

The nervous system, which has been observed in all the orders of the Acephala, consists of a central and a peripheral portion.

The first is composed of one, or several (usually three) ganglia; the second consists of nervous trunks of variable size, which pass off in the most different directions. When the number of these ganglia is considerable, they are arranged in pairs which are situated more or less near the median line, according to the different regions of the body. The ganglia of each pair intercommunicate by a transverse commissure of variable length. They connect, moreover, with others, which are even far removed, by anastomosing filaments. It is difficult to decide which of these ganglia is the brain. Many species want a complete ganglionic ring surrounding the buccal cavity.

§ 182.

From its extreme softness, the internal structure of the nervous system of the Acephala is very difficult of study. Its primitive fibres are very delicate, and are surrounded, in the nervous trunks, by a distinct and very thin neurilemma. In the ganglia, through which orange-colored granules are usually scattered, these fibres pass into a very loose tissue composed of small transparent vesicles, which probably take the place of the ganglionic globules which are so distinct with other invertebrates.

§ 183.

1. The nervous system is most simple with the Tunicata. It here consists of a single ganglionic mass, which is subcutaneous, and situated between the two respiratory tubes.

1 Carefully examined, Anomia will be found to have three unequal adductor muscles arising from the imperfect valve. The largest of these, together with one of the others, passes into the fissure of the other valve; while the third is inserted upon the same valve.

2 It has already been remarked (§ 177), that with the Brachiopoda the peduncle receives muscles both from the body and from the valves. It has, moreover, muscles of its own, and ought, therefore, to be contractile. This contractility is quite prominent with the very large and long peduncle of Lingula, especially in comparison with the very short, sucker-like one of Orbicula. Externally, it is composed of a thick cartilaginous tissue, while its interior is occupied by a hollow, muscular cord, composed of longitudinal filaments; see Owen, loc. cit. (Terebratula), and Vogt, loc. cit. Tab. 1. fig. 1–6 (Lingula).

3 These orange-colored ganglia are quite distinct with Unio, and Anomia. Although the Naiades have very large ganglia, yet their microscopic examination has furnished no further results, for neither by the compressarium, nor by chemical means, can these globules be separated from the intervening tissue.
With the Palinacea, the central nervous mass is upon the dorsal surface in front of the middle of the body. It consists of many closely-aggregated, yellowish ganglia, from which nerves pass off in all directions.

With the Ascidiae, it consists of a single large ganglion, which is easily found within the muscular envelope, in an angle formed by the oral and anal tubes. The nerves which pass off in different directions from this ganglion, belong chiefly to the muscular envelope. Some of them, however, pass to the organs of sense situated near the two respiratory tubes, and form around the orifice of that one of them which is buccal also, a complete circle which corresponds perhaps to an osophageal ring.

2. The nervous system of the Brachiopoda is as yet little known. However, from the presence, in some species, of two or three ganglia about the oesophagus, it may be concluded that it is analogous to that of the Lamellibranchia.

3. With the Lamellibranchia, the nervous system is the most distinct. Its very symmetrical arrangement is prominent, except in the unequivalved species.

1 Meyen was the first to describe with care this nervous mass with Salpa; for, before him, many other parts of the animal had been carelessly taken by Swinning (Mem. &c. II. p. 127), and Campano (De Salpa, &c. p. 5), for the nerves and ganglia; see Meyen, Not. Act. Acad. Leop. loc. cit. p. 294, Tab. XXXVII. fig. 8, 15 (Salpa pinnata), Tab. XXXVIII. fig. 5, h. 12 (Salpa mucronata). Quoy and Gaimard have also observed a central nervous system in the dorsal region of several Salpa; see Voyage de l'Advertisement. Zool. III. p. 593, and the Atlas zoologique of the same, Molusques, Pl. XXXVI; or Linné, 1836, p. 110, Tab. VI.

Eschricht's description is still more minute; but he has taken for the central nerve that portion of the body in which this lobulated ganglionic mass is situated; see his Memoire. Over Salpeme, &c., p. 12, Tab. II. fig. 8, 10, n. (Salpa cordiformis), and Tab. III. fig. 22 (Salpa zoaropterus). See also, Delile Chaja, Descri. &c. III. p. 45, Tab. LVIII. fig. 3, n. 12 (Salpa maxima). I am yet of opinion whether the nervous ring, which, according to Eschricht, is formed by the junction of the two nerves surrounding the anterior respiratory orifice, really corresponds to the osophageal ring.

2 A very detailed description accompanied with figures of the nervous system of the simple Ascidiae, may be found in the works of Cavier (Sur les Ascidiae, &c. loc. cit. p. 24, Pl. II fig. 2 C 3, g. III. fig. 2, c. (Cygonus and Phallusia); Eschricht (Eschricht's Beschreibung der Chydonier, loc. cit. p. 8, 9, 4, c.); Delile Chaja (Descri. &c. III. p. 2v. Tab. LXII. fig. 2, and LXIV. fig. 3, 5, (Phallusia); and Swinney, who has included also the compound Ascidiæ (Mem. &c. p. 32, Pl. IX. fig. 21. XI. fig. 1, D*. (Phallusia); also Pl. XXI. fig. 1, XXII. fig. 1, XXIII. fig. 1, D*. (Intrylythus and Pyrosoma). The principal ganglionic masses is always nearer the anal than the oral tube, and does not give off branches except at its extremities. The nerves ring of the Ascidia, has been observed by both Cavier, and Delile Chija.

The last of these authors has also mentioned a particular ganglion which he has observed with Phallusia monilalis, in this ring, and which he regards as the brain; while he has given the name of Ganglion sympathetic to a principal ganglionic mass, lying near the anal tube.

2 Cavier (Sur la Légumière, loc. cit. p. 8) thinks he has observed two ganglia at the base of the arms, but which give off no nerves. Owen (loc. cit.) has found two ganglia in front of the osophageal mass of Orbicularia, and one behind it; and also two nerves arising from the two anterior ganglia attended with two arteries which go to the two hearts.

The nervous system of the Lamellibranchia was discovered by J. Rauthé. In 1797, he had well represented the anterior pair of ganglia of Atedonta (loc. cit. p. 162, Tab. IX. fig. 10, 11). Forl, it is true, had already figured the nervous system of several species of this order (loc. cit. Tab. XXXVI. fig. 1, n. (Pinnata); Tab. VIII. fig. 1, l. (Pholas); Tab. IX. fig. 10, a. (Ulaia); Tab. X. fig. 15, Tab. XI. fig. 1, Tab. XII. fig. 6, (Solen); Tab. XV. fig. 1, (Arotura); Tab. XXXII. fig. 18, r. (Mytilus). But he erroneously took it for a lymphatic system.

The following works may be consulted upon this subject: Monetti, Nuove ricerche zool. sopra alcune specie di conchiglie bivalvi, Milano, 1861 (translated in Reis's Arch. IX. 1865, p. 215, Tab. xg. (Annodonta) Brandt, Meditizia. Zool. II. p. 310, Tab. XXXVI. fig. 16, 12 (of the Oyster); Garnier, On the Nervous System of Moluscs Animals, in the Rees, of the Linnean Soc. XVII. 1857, p. 189, Pl. XXIV. (Ostrea, Pecten, Modiola, Mottra, Mya, and Pholas); and, on the Anatomy of the Lamellibranchia, loc. cit. p. 89, Pl. XIX. fig. 5 (Ferunierius); Keber, De Nervis Conchaeae, Diss. Berolini, 1837; Dauvroy, Sur Panimal de Pongue, in the Ann. des. Sc. Nat. XVIII. 1843, p. 113, Pl. V. B. fig. 8; and, Sur le Systéme nerveux des Molusques Acéphales bivalves, in the Comp. rend. 1844, Nos. 22, 25, 1845, No. 8, and in Frémy's note Noue. 1846, No. 784. Blaneckarda, Observ. sur le Systéme nerveux des Molusques Acéphales testa tes on Lamellibranches, in the Ann. des. Sc. Nat. III. 1844, p. 323; Pl. XIII and in Frémy's note Nou. No. 741 (Solen, Mottra, and Pecten); and John Anderson, Art. Nervous System, in the Cyclopaedia, of Ann. III. 1804.

* * *[183, note 4] See also, Duvernoy (suite) Compt. Rend. XXXIV. 1852, p. 685, and XXXV. 1852, p. 119; also, Frey and Leebeck, loc. cit. p. 46; Dehays, loc. cit. p. 60, Pl. VIII. IX.; and Quatrefages, loc. cit. p. 63, Pl. I fig. 5, 6 (Tereus). — Ed.
A. The central nervous mass is composed of three pairs of principal ganglia, as follows: *Par anterius* or *labiale*, *Par posterior*, and *Par inferius* or *abdominale*. This last pair is extraordinarily developed with those species which have a foot, and has, therefore, received also the name of *Par pedale*.

The ganglia of the *Par anterius* are situated one on each side of the digestive canal, and are connected by a filament which extends arcuately over the circumference of the oral cavity.\(^5\) They send off two long nerves, which pass along the back to the *Par posterior*, which is the largest of all and usually situated upon the anterior surface of the posterior adductor muscle. Its two ganglia are either blended together, or connected by a transverse commissure.\(^6\) In this way, the anterior and posterior pairs with their commissures form a kind of oesophageal ring which surrounds the base of the abdomen.

The inferior or pedal pair is situated at the point where the base of the foot is joined to the abdomen. Its ganglia are contiguous upon the median line, or are blended together into one.\(^7\) They connect also with the labial ganglia by two nerves, thus forming a second oesophageal ring.\(^8\)

Besides these principal ganglia, there are others, smaller, and situated in various parts of the body. But these are not constant, for their presence is always due to an unusual development of the muscular system.

B. The peripheral nerves arise almost exclusively from the three pair of principal ganglia, for the nerves of connection do not usually give off branches. The few and very delicate filaments which sometimes pass off from these last, belong probably, to the splanchnic system, for the principal ganglia appear to furnish only sensitive and motory nerves; these are usually distributed in the following manner:

The *Par anterius* sends nerves to the anterior part of the mantle,\(^9\) to the anterior adductor muscle, and to the tentacles of the mouth and its circumference.

The *Par posterior* sends two very large trunks to the branchiae; also other nerves to the lateral and posterior part of the mantle,\(^10\) to the posterior adductor muscle, and dedicate filaments to the heart and rectum.

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\(^5\) The length of the arc of this filament of connection depends upon the position of the two labial ganglia. Thus with *Pecten*, where these ganglia are situated unusually in the rear, this very long and very arched; while with *Pholas* and *Solen*, where they are close upon the oral opening, it is short. With *Unio*, and *Mactra*, these ganglia lie so close to each other, that this anastomotic filament is replaced by a very short, transverse commissure.

\(^6\) The *Par posterior*, which, from its relations to the branchiae, is also called the *Par branchiale*, is blended into a single ganglion in those species whose branchiae are united at their lower part; as *Unio*, *Anodonta*, *Mactra*, *Mya*, *Solen*, and *Pholas*. On the other hand these ganglia are separate, and connected simply by a transverse commissure, with those whose branchiae are isolated; as *Ostrea*, *Pecten*, *Arctica*, *Mytilus*, *Lithodoma*, *Mollusca*, and *Arca*.

\(^7\) According to the earlier Zoodomists, the *Par pedale* was wanting in these species which have no foot, although careful investigation has shown that there is a pair corresponding to the *Par inferius*. I refer to that found with *Ostrea* (Brady, loc. cit. Tab. XXXVI, fig. 11, n. 6), directly behind the labial ganglia, and with *Pecten* (Grube, *Muller's* Arch. 1840, p. 33, Tab. XI, fig. 3, g, j and Blancharcd, loc. cit. p. 355, Pl. XII, fig. 3, a, b), between these ganglia with which it is in connection by commissures.

\(^8\) Of these three ganglia, the *Par anterius* has often been regarded as the brain. But others have rather taken the *Par posterior* for the principal nerves mass. For my own part I think that all three, together with their commissures, correspond to the pharyngeal system of *Gasteropoda*.

\(^9\) The anterior nerves of the mantle of *Solen*, which is prolonged far beyond the oral opening, and is strengthened by a muscular mass — have ten to twelve ganglia lying along the border of the mantle. With *Pecten*, the mantle-nerve has also a small ganglion upon the muscular mass which is found upon each side of the anterior border of this organ; see Blancharcd, loc. cit. p. 355, Pl. XII, fig. 1, f. (Solen), fig. 3, c. (*Pecten*).

\(^10\) In the mantle of *Ostrea*, *Spondylus*, *Pecten*, *Lima*, and in general those species in which its borders have numerous sensitive organs, the branches of the anterior and posterior mantle-nerves unite and form a common marginal nerve whose size depends upon the number of the sensitive organs to which it sends filaments.
The siphon and its muscular apparatus receive their nerves also from this same pair. (1)

The nerves of the Par inferius being destined chiefly for the foot, correspond in number and size with the degree of development of this organ. This number, however, varies between two and six for each side.

§ 184.

The Acéphala have, certainly, a Splanchnic nervous system, but as yet it has been found only with the Lamellibranchia; (2) and even here it is seen with difficulty and imperfectly on account of the extreme tenuity of its filaments.

With some species, delicate, lateral filaments pass off from the nerves of communication, which connect the Par gangliorum inferius and posterius with the Par anterius; these may be properly termed sympathetic nerves, for they are distributed partly to the walls of the digestive canal, and the heart, and partly to the liver, the gland of Bojanus, and the genital organs. (3)

CHAPTER IV.

ORGANS OF SENSE.

§ 185.

Of the organs of sense with the Acéphala, those of Touch are the most highly developed. They usually consist of conical, or flattened, protractive prolongations of the skin, which are extremely irritable, covered with ciliated epithelium, and often of a deep color.

(1) When the two retractor muscles of the siphon are large, as is the case with Solen, Maetra, Ves- nus, and Cytheres, their two nervous trunks have several splanchnic enlargements along their course, connected by transverse filaments; see Blanchard, loc. cit. p. 333, Pl. XII. fig. 1, 2, d. (Solen and Maetra).

With the simple Ascidiae, as a sympathetic system may perhaps be considered the ganglion, which, according to Schalk (loc. cit. p. 9, fig. 4, g, q.) is concealed between the intestinal convolutions, at the posterior extremity of the body of Phallus. and sends off filaments in various directions. But, as yet, the existence of this ganglion needs confirmation.

(2) Garner, Duverney, and Blanchard have seen the filaments, which issue from the principal ganglia, enter the vegetative organs; but as they could not further trace them, they hesitate to regard them as organic nerves. Rest is more positive in favor of the existence of a sympathetic system with the Lamellibranchia. He has observed (loc. cit. p. 15) that the commissural filaments, which pass into the Par posterius, give off branches to the intestinal canal, to the liver, and gland of Bojanus; and that those of the Par pedale give off similar branches to the genital organs; and also that these nerves form several Vesius between these organs, and from which are given off filaments to the heart. From this disposition, he ought to conclude that these are real organic nerves.

If this is so, the same signification would be given to the nervous filaments which Blanchard (loc. cit. p. 336, Pl. XII. fig. 1, c,) has seen arise with an Area, and a Solen, from the two small ganglia which belong to the commissures of the Par posterius. More profound researches upon the destination of their nerves, must determine whether the two ganglia situated between the bilateral ganglia, with the special Lamellibranchia (see above § 183 note 1), really correspond to the Par pedale, or do not rather belong to the sympathetic system.

* [§ 183, note 11.] See Quatrefoles (Mém. sur le genre Thulet, in Ann. d. Sc. Nat. 1849, XI. p. 68, Pl. 1), who has described in detail this system with the Teredina. — Er.
With both the simple and the compound Ascidiae, there are, at the base of the oral tube and at the entrance of the respiratory cavity, numerous filiform and sometimes fringed tentacles inserted upon a kind of ring.(1) With the Lamellibranchia, there are often conical tentacles around the respiratory and anal openings of the mantle,(2) and the orifice of the siphon. Among those which have an open mantle, there are many the borders of whose mantle, either wholly, or only posteriorly,(4) are provided with thickly-set conical tentacles. These receive all their nerves from those of the mantle.

Instead of these retracted tentacles, the Brachiopoda have long radiating bristles upon the borders of their mantle. These project a considerable way beyond the borders of the valves, and having perhaps sensitive nerves at their base, they are thus tactile organs like the vibrissae of some Mammalia.

The oral opening of all the Lamellibranchia is provided, moreover, with two pairs of contractile, foliated lobes, pointing backwards, which are perhaps oral tentacles. Each pair is composed of two lobes, an internal and an external, which are united at their base, and whose surfaces lie against each other. Behind, the border of these four lobes is somewhat thinned, while in front, the two on the same side usually pass into each other, the external being above, and the internal below, the oral opening. The free surfaces of the lobules are smooth and covered with a very thin epithelium, while the other and opposite surfaces are fringed transversely throughout, and the borders of these fringes are fringed with very large vibratile cilia.(2)

As tactile organs, may be mentioned the two remarkable arms which, with the Brachiopoda, are spirally rolled up near the oral opening. The long, pectinate fringes upon their borders are united at their base by a soft, hollow membrane which is probably contractile, and is provided with vibratile cilia.(10)

1 See the figures in Savigny, Mem. &c. loc. cit.
2 Cardium, Chama, Tribulacea, and Isocardia.
3 Salpa, Pholas, Aspergilium, Macra, Pectona, Donax, &c. With Donax trunculus, the respiratory tube is remarkable for its ramified tentacles: see Poli, loc. cit. Tab. XIX. fig. 15-20.
4 Unio, Anodonta.
5 With Donax, Macra, and Tellina, this row of tentacles is simple; but it is multiple with Ascula, Asocula, Ostrea, Pectona, Spondylus, and Liuma.
6 See Owen, and Vogt, loc. cit.
7 As to the oblong organ which, with Salpa cordiformis, projects into the cavity of the body as two parallel cutaneous folds between the anterior respiratory opening and the central mass of the nervous system, I am yet undecided whether or not it corresponds to the tactile lobes of the Lamellibranchia. It appears smooth upon its free border, and receives, at its transversely striated base, two nerves from the principal ganglia. With Salpa zonaria, a similar organ lies directly in front of the central nervous mass; see Eckelhain, Over Salpa, loc. cit. p. 14, fig. 8, 10, 22, t. With Salpa macrona, this singular organ is situated in front of the nervous centre, and has been taken by Meyen for a male genital organ; see Uchber die Salpen, &c., p. 397, Tab. XXVIII. fig. 5-10.
8 Ascudaria, Isocardia, Pinna, Cardium, Pectunculus, Macra, Anodonta, Aspergilium, &c. But Spondylus and Pecten form, in this respect, an exception. Here, the lobes upon each side, instead of being continuous, are separated by numerous curiously-branched tentacles which surround the oral orifice and strikingly resemble those surrounding the mouth of certain Holothurians when contracted; see Poli, loc. cit. Tab. XXII. fig. 8, 14, 14, XXVII. fig. 6, 10.
9 The branchial bands of the Lamellibranchia have these fringes upon all their surfaces, and in their outward aspect closely resemble these tactile lobes. It is therefore probable that, like the oral tentacles of the Polyzoa and Holothurians, they have a varied function. Thus, they could serve not only as gustatory organs for the food entering the mouth, but also as those of ingestion, besides taking a part also in the respiration.
10 The researches of Courrier, Owen, and Vogt (loc. cit.) upon the arms of the Brachiopoda, were made upon specimens preserved in alcohol.

The relations, therefore, of these organs and their fringes during life are not known. Muller also (Zeit. Dianica, i. p. 4), and Poli (loc. cit. ii. p. 190, Tab. XXX. fig. 22, 23), say nothing upon the motions of the fringes of Oriculata and Terebrata. If they are really contractile and ciliated, the whole apparatus is quite analogous to that of the Myxomastia.
§ 186.

As yet, organs of hearing with the Acephala have been found only among the Lamellibranchia. They are here feebly developed, consisting only of two simple round capsules filled with a transparent liquid. Their very thick and somewhat solid walls are homogeneous and transparent; they enclose a vitreous spherical otolite, of a crystalline structure, and composed of carbonate of lime. These otolites constantly keep up very singular swinging and rotary motions, which instantly cease, however, when the capsule is ruptured. These auditory capsules when present, are situated in the foot in front of the pedal ganglia with which they always communicate, either continguously, or by two auditory nerves which they receive.

§ 187.

Organs of vision are very common with the Acephala, and always many in number. With some, they occupy a large portion of the borders of the mantle; with others, they are confined to the external orifices of the longer or shorter mantle-tubes.

1. These organs were first noticed by me with the Natica, Cardiacea, and the Pyloridiae; but were regarded as of a doubtful nature. Since then, after comparing them with the auditory organs of the embryos of fish, I am satisfied that they are really very simple organs of hearing; see Müller's Arch. 1853, p. 49, and Wiegmann's Arch. 1841, I. p. 149, Taf. VI. fig. 1, 2 (Cyclosa enara); also, the Ann. d. Sc. Nat. X. 1838, p. 319, XIX. 1843, p. 195, Pl. II. B. It appears, moreover, that similar corporons are found in other orders of these animals. Thus, Delle Chiote mentions with Salpa polinotiana, an organ situated above the nervous centre which exactly resembles the auditory capsules I have discovered in the foot of Cyclosa. Un fortunately he has neither figured nor carefully described this organ (Descri. &c. III. p. 45, Tav. LXVI. fig. 1, l.). Eßdrioh (Ann. Breskiv. d. Chelyloma Machejannum, p. 9, fig. 4, 6, d. 7, and fig. 5) has also regarded as an auditory organ a remarkable appendage which he saw near the nervous centre of a simple Ascidian. This consists of a pyriform vesicle filled with whitish matter, and of a claval body, which he describes in large detail, a fissure and two lateral depressions.

Delle Chiote's figure (Descri. &c. III. Tav. LXVIII. fig. 4.), of the principal ganglion mass of Cyclosa papillata, reminds me of the claval body of Chelyosoma and leads me to think that this author has confounded it with the nervous centre. I think that this organ exists generally with both the simple and compound Ascidiae, for Sartory has noticed with Cysthina, Phialusia, Apodium, Polyptilum, Batylus, Eucelium, Syncereus, Pyrosoma, &c., two tubercles near the nervous ring which surrounds the respiratory tube (Tubercule antérieur et postérieur). And, to judge from his figure (Memb. Sc. Pl. VI. fig. 12, 4, l. Pl. VII. fig. 2), of one of these tubercles, with Cysthina, these organs appear analogous to the claval body just mentioned. At all events, these tubercles deserve, with Zoologists, more attention than has hitherto been given them.

2. These motions are probably due to the ciliated epithelium lining the cavity of the capsule; see, below, the auditory organs of the Gastropoda.

I have been able as yet to find these capsules with the aspidal Lamellibranchia,—at least, with Terebellum, and Mytilus. They appear to exist, however, very feebly in Deshayes' specimens both in Argo and Teredo. Here they were situated at the extremity of the septa lying between the pericardium and the elevator of the gills, and upon which the anterior extremity of the branchial is inserted; see Comp. rend. 1846, XXII. No. 7; or Forficel's next Nat. No. 812, p. 227.

4. With Cyclosa, and Tellina, the auditory capsules are contiguous with the ganglia of the Par pedale. With Anodonta, Union, Cardium, and Mya, they are a little removed.

1. Poli (loc. cit. II. p. 183, 167, Tab. XXII. fig. 1, 4; and Tab. XXVIII. fig. 5, 14, 15), was the first to compare human eyes these remarkable bodies, which, brilliant as diamonds, lie upon the borders of the mantle of Pecten and Spondylus, with this expression: Ocelli smaragdino colore coeruleantet. Nevertheless, it is only of late that these organs have received much attention. Gard- ner (On the Annt. of the Lamellibr. Conchif. &c. Pl. XIX. fig. 1, c. 3) was the first to notice under the Ocelli of Pecten. Grant (Quinines, &c., p. 258) has described these of Pecten and Spondylus as organs long known. Grube (Müller's Arch. 1840, p. 24, Taf. IV. fig. 1, 2), and Röhn (Hist. Pfl. p. 381, Taf. IX. fig. 10) have described the structure of these organs, and, quite recently, Will (Froicel's new Nat. 1844, No. 622, 623) has treated this subject most profoundly.

Deshayes is not satisfied of the existence of organs of Vision with the Pectinidae, while Duer recently regards as such the bodies situated on the border of their mantle (Inst. 1845, p. 52, 88). It is astonishing that Deshayes should have denied eyes to the Pectinidae, where they are so complete. He could have better denied them to Phialusia, Area, Ostrea, and other Acephala. During my last visit at Venice and at Trieste, I examined living individuals of the genera Area, Ostrea, Pinna, as well as other Lamellibranchia and various Ascidiae; but with all possible care, I was unable to verify Will's description (loc. cit.) of the eyes of these animals. In most cases, the bodies which he has described as eyes, have appeared to me as simple existences of the mantle, which are variously colored, but are wholly without the indispensable optic apparatus for a visual organ.
Each eye is composed of a ball formed of a fibrous Sclerotica, which is situated upon a small eminence, or is sunken in a contractile prolongation of the mantle from which projects a cornea, covered by the general skin. Within the sclerotica there is a reddish-brown pigment which is continuous in front into a brownish or bluish-green Iris which has a circular pupil; while behind, at the base of the eye, it has the appearance of a kind of Tapetum. This is composed of staff-like corpuscles, which produce that beautiful emerald-green appearance of the eyes of certain species.

The Retina surrounds a vitreous body, composed of non-nucleated cells, and which receives in front a very flattened crystalline lens. The optic nerves which enter the eye-ball at its posterior part, are, together with those of the tentacles, received from those of the mantle, and especially from the marginal branches.2

The following are the modifications which have already been observed with the eyes of these animals:

With the Ascidiae, there are eight eyes at the entrance of the respiratory tube, and six of a deep-yellow color at the entrance of the anal tube. They are situated in the special fissures around the openings, and in the midst of a mass of orange-colored pigment.3

With Pholas, Selen, Venus, and Mactra, these organs are very numerous and non-pedunculated, and are situated at the base of the tentacles surrounding the two orifices of the siphon. With Cardium, the borders of the orifices of the short siphons have an extraordinary number of protractile tentacles which can be protruded through the open valves, each of which bears an eye of diamond brilliancy.4

With Tellina, the two borders of the mantle have small, reddish-yellow, pedunculated eyes, which are quite numerous at the posterior portions.

With Pinna, the anterior part of the mantle near the adductor muscle has, on each side, about forty brownish-yellow eyes situated upon short peduncles. But with Arca, and Pectunculus, the numerous reddish-brown eyes, usually sessile, are scattered irregularly over the borders of the mantle.5

Anomia has about twenty brownish-yellow sessile eyes concealed among the tentacles, upon each border of the mantle. With Ostrea, the number is still larger; for, for more than a third of the length of the mantle, there is a very small short-pedunculated yellowish-brown eye between every second tentacle.

But the beautiful emerald-green eyes of the Pectinea are the most remarkable. They are pedunculate and situated between the tentacles of the marginal fold of the mantle, being very much more numerous upon the side of the plane, than upon that of the convex valve.6

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2 See Garner, loc. cit. fig. 3; Krohn, loc. cit. fig. 16, and Graber, loc. cit. fig. 2.
3 Phallusia, Cynthia, and Clavelinna, according to Will, loc. cit. No. 625, p. 192. Grant (Out- lines, &c., p. 361) has seen, at least with Phallusia, these fourteen eyes.
4 See Will, loc. cit. p. 100. The color of the eyes appears reddish blue with Mactra, and of a yellowish brown with others.
5 See Will, loc. cit. The pupil is an elongated oval with Pinna. With Pectunculus pilous, the very numerous eyes are partly isolated, and partly grouped in twos and threes.
6 Beside the figures already cited, all of which belong to Pecten and Spondylus, see also those which Delé Chejka (Besitz, &c. Tav. LXXV, LXXXVI.) has given of the eyes of Pecten. In this same genus, Will has seen sixteen to twenty-four of these organs upon the convex portion of the mantle, and thirty-five to forty-five upon the plane portion; and with Spondylus guadenerous, sixty upon the convex, and ninety upon the plane side.
CHAPTER V.

DIGESTIVE APPARATUS.

§ 188.

The digestive canal of the Acephala is formed, throughout the class, upon a single plan. It always consists of irregular convolutions which are separated with difficulty, for their walls are generally not covered by a peritoneal envelope, but are intimately blended with contiguous organs and especially the liver and genital gland. The oral and anal openings, which are always present, are not upon the surface of the body, but are situated in a cavity circumscribed by the mantle. 10

The mouth has always tumid lips and often tentacular appendages. Its cavity has neither distinct muscular walls, nor any trace of a masticatory apparatus. It passes either directly, or by a short oesophagus, into a kind of stomach which gradually contracts into a longer or shorter intestine, scarcely different from it in its intimate structure. The extremity of the intestine often projects into the cavity of the body, as a kind of papilla, upon the end of which the anus is situated. Internally, this canal is lined throughout with a very distinct, ciliated epithelium.

The food of these animals, which consists of slime and small organized bodies, is taken into the cavity of the body with the water, and is conducted to the mouth by the ciliated epithelium which lines this last. In a similar manner the faeces are rejected with the refuse water.

§ 189.

The very feebly-developed digestive canal of Salpa consists only of a small knob (Nucleus) situated in the posterior part of the cavity of the body. It connects with a furrow formed by two narrow folds situated along the ventral median line.

This furrow may become a canal by the joining of its borders, and its posterior extremity, which is a little lateral, opens directly at the entrance of the intestinal canal which is surrounded with a lip, and ought therefore to be regarded as a mouth. The folds of this furrow arise directly behind the anterior respiratory orifice, and are very probably covered with cilia, by which, solid particles of food taken into the body during respiration, are borne towards the mouth.11

1 With many Acephala, as with the Ascidiae and Salpinea whose mantle is entirely closed with the exception of the two respiratory orifices, it is only in an improper manner that the terms oral and anal can be given to these orifices.

1 With Salpa cardiformis, and maxima, I have seen this furrow quite distinctly. It appears to be present in all species. Cuvier has already mentioned and figured it (Mém. sur les Thalides, &c., p. 13, fig. 1, 2, 3, &c., η.), and it has also been noticed by Sulpiz (Mém. &c. p. 134, Pt. XIV. fig. 1, 2, 1.), and Eschricht (Over Salperne, p. 26, fig. 4, 5, 18, m.) but they describe it as a dorsal furrow and a dorsal fold, for they have taken the abdominal cavity of these animals for the back. That of Salpa rubra is quite distinctly figured in the Catalogue of the Physiological Series, &c., I. Pt. VII. fig. 1, k. This furrow corresponds, probably, less to an open oesophagus, than to the tentacle-furrow, which, with all the Lamellibranches, is situated upon the two sides of the mouth.
The intestinal canal is short, without a distinct stomach, and somewhat spirally convoluted. Its extremity opens by a large anal orifice near the mouth.

With the Ascidiae, the intestinal canal is quite distinct. The mouth is situated in the respiratory cavity, far removed from the so-called oral tube, or more properly speaking, the respiratory orifice. It is surrounded with thick lips, and has at its posterior extremity with many species, a semi-canal closely resembling, and undoubtedly of the same signification as the ventral furrow of Salpa. This canal is formed by two narrow folds arising below the circle of tentacles which surround the interior of the oral cavity; it passes along the large curvature of the respiratory cavity, and rising upon its opposite side, ends, after a longer or shorter course, below the oral cavity. The mouth opens into a short oesophagus, and this last ends in a long or round stomach, which is often quite circumseriated and plicated longitudinally on its inner surface. The intestine passes first towards the base of the body by a short arch, then by a longer one it rises towards the mouth, and thence passes to the anal tube, opening, by a fringed anus, sometimes close behind the mouth, and sometimes further below it.

With the Brachiopoda, the mouth is simple and concealed between the base of the two tentacular arms. With Terebratula, the oesophagus is very long and curving, opening into a large stomach; but with the other Brachiopoda, the stomacal dilatation is wanting, and the intestine is simply convoluted. With Orbicula, and Terebratula, the intestine is short, and has only a single convolution which passes to the right and terminates in a lateral anus hidden between the lobes of the mantle. But with Lingula, it is much longer, and its turns are quite numerous; the anus here is lateral also, and opens through a small papilla which projects from the cavity of the body into that of the mantle.

With the Lamellibranchia the intestinal canal is highly developed, but always buried in the midst of other abdominal visceras. The mouth, situated at the bottom of the cavity of the mantle, and beneath the anterior adductor muscles, is surrounded by two pairs of tentacles in the form of tactile lobes; these often form a narrow leading to the mouth, and along which pass the particles of food drawn in by the cilia. The mouth opens, either

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2 See Home, Lect. on Comp. Anat. II. Pl. LXIX. (Salpa Tigitii),
3 For the oral and anal orifices of Salpa, see the figures of Carpenter, and Savigny, loc. cit. Some species however differ from the descriptions here given. Thus, according to a preparation in Houter's Museum, the isthmus of Salpa gibba has two eaudal appendages (Home, Lect. &c. Pl. LXl. fig. 2, 3, and Catalogue of the Phys. Series, I. p. 152, Pl. VII. fig. 1, 2, 3.) The intestinal canal of Salpa pianata presents a still more remarkable exception. No nucleus is formed, but the mouth opens directly into the stomach which is curved and ends off an intestine in front, and the anal orifice is situated near the anterior extremity of the ventral groove; see Carter, loc. cit. p. 11, fig. 2; Home, loc. cit. Pl. LXIX. fig. 2, and the Catalogue of the Phys. Series, I. Pl. VI. fig. 4.
4 Savigny has described this canal with the most different Ascidians as a Silian dorsal; see the figures (loc. cit. Pl. VI. &c.) of Cynthia, Phallusia, Dicoma, Synia, Apodina, Eoecina, Polyheurum, Botryllus, Pleroria, &c.
5 Carus also has called the attention to this canal with Cynthia microcosmica. (Nov. Act. Acad. Physico-Med. loc. cit. p. 432, Tab. XXVII. fig. 1, 2, 45.)
6 With Phallusia intestinalis, there is opposite this canal and upon the side of the respiratory cavity corresponding to the anal tube, a longitudinal row of very long thickly-set filaments, extending even to the oral aperture. Eschricht has seen a row of similar tentacles with Chelaosoma; see loc. cit. p. 10, fig. 4, 6, 7.
7 The stomach is elongated with Botellia, Phallusia, Cynthia, Sigillina, and spherical with Apodina, Eoecina, &c. Its longitudinal flods are often very distinctly marked externally by deep grooves, as is the case with Sigillina, Apodina, and Botryllus; see for this, Savigny, loc. cit.
8 According to him also there is a small cavity at the base of the stomach with Botryllus Schlosseri, and polycya; see Mem. &c. p. 201, Pl. XX. fig. 55, Pl. XXI. fig. 19, 26.
9 Upon the course of the intestine with the Asci-
10 See the figure given by Owen, loc. cit.
11 For the intestinal canal of several Brachiop-
oda, see Carter, Owen, and Foggt, loc. cit.
12 With Cardium, Isocardia, Acicula, &c., these two pairs of gustatory lobules are very distinctly seen passing towards the mouth by as many lateral
§ 190. THE ACEPHALA.

directly, or by a short oesophagus, into a large stomach lined with numerous papillae and apparently perforated by many biliary canals. The intestine, when short, forms a single arch only; but when long, it has many convolutions; it terminates in a rectum which lies along the dorsal surface of the abdomen, and passes between the lobes of the mantle, under the hinge and above the posterior adductor muscle, finally terminating above in a ciliated anus, situated upon a small prominence. With the majority of this order, the rectum traverses the heart.

There is often, near the pylorus, a long cæcum extending between the convolutions of the intestine to the lower extremity of the abdomen, and which contains, through its whole extent, a cylindrical transparent cartilaginous body—the so-called crystalline-stalk. A longitudinal fold extends along the inner surface of the entire intestine and a large part of that of the rectum, and thereby the intestinal surface is increased.

§ 190.

The anterior portion of the digestive canal of the Acephala is entirely without a Salivary gland. The Liver, however, is always present; it is

grooves, whose borders as already mentioned are blended above and below with the oral orifice. With Pectenulus, and Area, there is a still more remarkable arrangement.

Their lobes of this kind consist only of two narrow folds upon each side of the mouth, and between which is a transverse furrow, resembling the ventral-groove of Sula, or the semi-oval of the Ascidiae. The important part which this apparatus serves in the preparation of food, can be seen by covering those of Anodonta and Unio with a powdered colored substance.

This powder is carried by cilia from the surface to the borders of the tentacles, thence upon their transversely grooved internal surfaces even into the angle formed by these last, thence into currents of the grooves, and so direct into the mouth.

A distinct but short oesophagus is found with Area, Chama, Pinnu, Cardium, and Mactra.

The intestine is short and has a single arch with Aplysia, Pecten, Area, and Chama. It is long and has a turn with Pholas, Tellina, Cardium, Mactra, Pinnu, Ostrea, &c.

The anus is short and situated directly behind the anal fissure of the mantle with Unio, Anodonta, Cardium, Bicyclic, &c.; while with Aspergillus, Lutraria and Solen, it is situated far removed from the siphon. With Area, Pectenulus, Pinnu, and Ancula, the rectum passes around a large portion of the adductor muscle and ends in front in a papilla, which, in the last two genera is quite long. With Lima, it ascends a little way along the anterior surface of the adductor muscle, and with Pecten and Ostrea, it leaves the median line upon the back of this muscle and passes obliquely towards the smaller valve.

To this, Area, Ostrea, and Teredo, form an exception, and especially with the last, where the intestinal canal is distinguished for several other peculiarities. Thus, the stomach is double and anteriorly divided to its base by a longitudinal septum; see Home, Lect. &c. pl. LXXX., and Deshayes, Comp. Rend. 1846, XXII. No. 7; or Pro- trippe's neue No. 813.

For the cæcum of Salaen, Mactra, and Cardium, see the figures of Garner, On the Anál. of the Lamellibr. &c. pl. XVIII. fig. 8-10; and for the disposition of the intestinal canal in general, see the Pistes of Poli, loc. cit.

According to Owen (Anat. of Clavigella, &c., pl. XXX. fig. 16, r.), Clavigella has a very short and rudimentary cæcum.

With the exception of Anomia, the crystalline stem is wanting in all the Monomya (Garner, loc. cit. p. 89). But it exists with many Dinuya, as Pholas, Solen, Area, Mactra, Donax, Cardium, Tellina, Anodonta, Unio, Mya, &c.; see Poli, loc. cit. Tab. VII. Xill. XIV. XVI. XIX. XX. XXXIV. With many of these, there is no cæcum and the crystalline stem is situated in the intestine itself. It has always a cylindrical form, and is of a decreased size at its lower end, while at the opposite site it is usually divided in several irregular lobes which project into the cavity of the stomach and appear close up the cilia of the biliary canals. With the Nipasides, where the cæcum is wanting, I have found this singular body, which extends from the stomach into the intestine, composed of a cortical and a medullary portion. The first which forms a kind of tube, is homogeneous, transparent, and formed of concentric layers or laminae, and the consistence of the white of an egg. The second is equally homogeneous and transparent, but is of a more gelatinous nature and contains a quantity of small granules (Unio), or batons (Anodonta), insoluble in acid, which, at the points where most aggregated, give this organ a whish color when examined by reflected light. According to Poli's description and figure of this organ with Pholas ductilis, it has an analogous structure with the other Lymulifronsia (loc. cit. I. p. 47, Tab. VII. fig. 11). As yet nothing positive can be said of the function of this organ. It may be also added that often with some individuals it is looked for in vain, while with others it is very distinct though variable as to its development and the number of layers composing its coriaceous portion. Hence it seems that it disappears at certain times, to be developed anew.

That of Anodonta as figured by Dujon (1827, Tab. IX. fig. 9, 10) was undoubtedly in the state of being formed, or disappearing.

Cuvier (Sur la Linguale, loc. cit. p. 7, fig. 10, 11, &c.) and cet (loc. cit.) have regarded the glandular mass which, with Linguale, opens into the digestive canal, as a solitary organ. But Owen (loc. cit.) is opposed to this view and says that all the
CHAPTER VI.

CIRCULATORY SYSTEM.

§ 191.

This system with the Acephala, as well as that of the Mollusca in general, is of a higher grade than that of the Zoophytes and Worms, in having the movement of the blood due always to a contractile central organ, or Heart. This heart is, it is true, very simple in some, but then with others it is so developed as to contain both auricles and ventricles. It receives the blood from the respiratory organs and distributes it over the body, and is therefore an Aortic heart. As to the blood-vessels themselves, the hitherto received opinions have been of late quite seriously objected to; and it appears very probable that all these animals have only arteries and veins,

glandular appendages of the intestine of Brachiopoda are hepatic organs. 2

2 The intestinal nucleus of Salpa owes its yellowish-brown color to these hepatic organs. But with Salpa democrita and caerulescens, it is of a beautiful blue color.

Salpa pliinata, whose straight intestine has already been mentioned, is distinguished also by its liver which is separated from and runs parallel with the intestine; see Courier, and Meyen, loc. cit. This last-mentioned author affirms that he has seen with this species a kind of green gall-bladder (loc. cit. p. 589, Tab. XXXVII. fig. 19, m.) but probably he confounded the stomach of the animal with its liver. For the intimate structure of the glandular layer upon the intestine of Salpa cordiformis, see Eschricht, Over Salpere, p. 27, Tab. III. fig. 20.

With the Ascidians, the liver is a simple glandular layer upon the stomach and intestine in the various species of Phallusia and Didazona; while with Cynthia, it is isolated near the pylorus, and composed of large follicles; see Savigny, loc. cit. Pl. XII. fig. 15 (Didazona).

3 With Terebratula, there are two groups of follicles opening into the stomach; with Orbicula, these are replaced by a mass of long hepatic ones; and with Lingula, by three principal glandular masses, opening at different points into the intestinal canal; see Orceh, Courier, and Vogt, loc. cit.

4 Poli (loc. cit. Tab. XI. XV. XVI.) has given a good representation of some hepatic lobes with their interanastomosing ducts of several species. See also Bojanus rotuig. figures of the liver and its ducts of Anodonta (fiss., loc. cit. p. 75, Tab. IX.)

As to the intimate structure of this organ, I have found with Cycicus cornea, lacustris, and rivulorum, Unio pictorum, and Tichognathus polymorphus, short, cylindrical, transparent filaments, a little thickened, but projecting stiffly from the base of the follicles into their cavity. I am yet ignorant as to their function, but have in vain sought for 6, with Unio batava, tumida, Anodonta anatina, cygnea, Mya arenaria, Cardium edule, and Mytilus edulis.

For the intimate structure of the liver of Lamellibranchia, see H. Muckel (Muller's Arch. 1845, p. 9, Tab. I.) and Karsen (Nov. Act. Nat. Cur. XXI. p. 262, Tab. XX.).

* [§ 190, note 1] Frey and Leuckart declare the presence of salivary glands with Terebro naviculotis; see loc. cit. — En.
§ 192. THE ACRPHALA.

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which are connected by no capillary net-work except that situated in the respiratory organs. The blood leaving the open ends of the arteries passes into the interstices (Lacunae) of the parenchyma of the body; thence it is taken up by the open mouths of the venous radicles.\(^1\)

The Blood is colorless and contains many pale, granular globules, which are indistinctly nucleated.\(^2\)

§ 192.

With Salpa, the circulatory system is composed of two main trunks, one upon the dorsal, and the other upon the ventral median line. At the anterior extremity of the body these trunks connect by two arcuate vessels; and at the posterior extremity by a single slightly-dilated canal situated directly in front of the intestinal nucleus. This last-mentioned canal is divided into several chambers by two or three constrictions, and, from its rhythmical contractions, may be regarded as a heart.\(^3\) It is surrounded with a delicate pericardium,\(^4\) and by its pulsations the blood is thrown across the walls of the body in different ways,\(^5\) thus forming extra-vascular currents. But it will here be observed that the heart, thus forcing the blood alternately in one direction and then in another, will regularly change the arterial into a venous current, and vice versa.\(^6\)

With the Acoelidae, this system is equally feebly developed. The blood passes for the most part out of the vessels into the lacunae which often consist of ramified canals resembling vessels. The Heart is always present, and is surrounded with a very thin pericardium. It consists of a long canal, which, at both extremities, passes into a vessel which lies loop-like between the vascular sac and the intestine at the lower part of the cavity of the body.\(^7\) Its pulsations quite resemble the peristaltic movements of the

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\(^1\) This effusion of the blood into the parenchyma of the body and its return into the veins without the intervention of capillaries, or in general without walled canals, has been maintained recently, especially by Milne Edwards (Observ. et exper. sur la circulation chez les Molinesques, Comp. Rend. XX. 1845, p. 291), and by Valenciennes (Nouv. observ. sur la const. de l'appareil de la circul. chez les Molinesques, Ibid. p. 769). Their observations were not limited to Salpa, and the Acoela, but were extended upon Ostrea, Pinna, Mucro, Venus, Cardium and Solen. See also Ann. d. Sc. Nat. 111. 1845, p. 283, 367, or Proctor's Nash. Nos. 732, 734, 735.

\(^2\) Milne Edwards is about to publish an extended work on the circulation with the Molusca. He has figured from his beautiful injections the partly circular system of Pinna; see Ann. d. Sc. Nat. VIII. 1847, p. 77, 78, 79.

\(^3\) For the blood of Phallusia, Cynadia, and Anoonta, see Wagner, Zur vergleichen. Physiol. d. Blutstr. Ht. I. p. 29, II. p. 40. The blood-corpuscles of the Nautilides have always appeared to me of an irregular form; and they run together when placed in a watch-glass. This is probably due to the fibrin cementing them together. When treated with acetic acid they become separated again, their contour becomes very clear and almost impereceptible, and a lividly transparent mesh is seen.

\(^4\) See Carter, loc. cit. p. 10, fig. 2, 9, 6. According to Meyer (loc. cit. p. 375, PL XXVIII. fig. 1, d.) the heart of Salpa macronota has two constrictions; and, according to Eschscholtz, this of Salpa cordiformis is divided into four chambers (loc. cit. p. 26, fig. 8, d).

\(^5\) Meyen (loc. cit. p. 376) has denied the presence of a pericardium with Salpa; but Curtier (loc. cit. p. 10), Sowerby (loc. cit. p. 127), and Delle Chiose (Desver. &c. 111. p. 43, Tav. XXVIII.) affirm the contrary.

\(^6\) The direction of these blood-currents in the body of Salpa is satisfactorily shown by the descriptions and figures of Quay and Gaimard (loc. cit.) and especially of Delle Chiose (Desver. &c.) Sars (Palm. med. Sc. p. 69) has also observed with Salpa ranunculata, that the blood beyond the aorta and vena cava, circulates in wall-less passages.

\(^7\) This remarkable alteration of the blood-currents which is possible only with a valveless heart, has been observed and described by different observers in a conformable manner. Before the heart changes the direction of its contractions it remains still for a short time, and this slackness the course of the blood-currents in the body a little, before they receive an impulse in the opposite direction; see Van Hasselt (Ann. d. Sc. Nat. III. 1824, p. 78), Eschscholtz (Mueller's translation of the annual report of the Swedish Academy upon the progress of Natural History, &c., 1825, p. 94), Quay and Gaimard (loc. cit. cit. p. 556, &c. Isis, 1826, p. 111), and Delle Chiose (Desver. &c. 111. p. 43).

\(^8\) For the heart and blood-system of the Acoelidae, see especially, Milne Edwards (see the Acoelidae composées loc. cit. p. 4), who has indicated the presence of the heart in Phallusia and Clavelina, as well as in Polycelis, Botryllus, Dilomena, Pyrosoma, &c.
intestine; and, as with Salpa, the direction of the current is changed so alternately that the two terminal vessels serve in rotation as an Aorta and a Vena cava. 80

The blood not only traverses the lacunae of the intestinal sac, but also penetrates the walls of the mantle, and even passes into the common support of the compound forms. In this last case, it circulates in ramified canals, which, as prolongations of the cavity of the body, extend even into this portion of the mantle. 90

With the Brachiopoda, this system is quite remarkable. The branchial afferent veins of the mantle do not open into a single heart, but into two hearts which are situated right and left of the intestinal sac. 90

These hearts, by pulsation, throw the blood into the intestinal canal, which ought therefore to be considered as a common visceral sinus. 90

With the Lamellibranchia, the heart, situated at the posterior extremity of the back, is divided, usually into three chambers, and surrounded with a large pericardium. Two lateral, triangular, thick-walled ariules receive the blood from the branchiae and send it into a simple muscular ventricle which is nearly always traversed by the reetum. Thence the blood passes into the body by a posterior and an anterior aorta. Its return into the two ariules is prevented by valves. 100

The walls of these ariules disappear after considerable ramification, and the blood passes into a system of lacunae which extends through the whole body and forms a net-work of sinuses and anastomosing canals. 100

The venous blood is received into special

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80 This change in the direction of the blood-current was first noticed by Lister (Philos. Trans. 1834, Pt. II. p. 365, or Wiegemann's Arch. 1835, i. p. 360) with Perophora, a new genus of the compound Ascidia; and Milne Edwards has since confirmed it with Pyrosmia (Ann. des Sc. Nat. XII. 1839, p. 375), and several other Ascidiae both simple and compound; see his Observ. sur les Ascidies simples et composées, p. 7.

These inter-alternating peristaltic and anti-peris
taltic motions show that the heart of the Ascidiae is valvless. It is therefore surprising that Delle Chiò's has described it with valves; but this is not the only point in which he differs from other observers on this subject, for he describes the heart of the Ascidiae as bifurcated into two ariules; see his Mem. &c. loc. cit. III. p. 189, Tav. XLVI. fig. 15, ab. (Cynthia papillata), and Descriz. &c. III. p. 29, Tav. LXXXII. fig. 11. (Phallusia inter
testinalis).

90 This circulation of the blood in the common Ascidian-stock has been observed by Lister (loc. cit.). Milne Edwards has seen also the ascending and descending currents in the ramified and cecal prolongations of the peritonal sac, in Batylus, Diazona, Didemnum, and Polyevolium; see Savigny, Nœn. loc. cit. p. 47; Delle Chiò, Descriz. &c. III. p. 34, Tav. LXXXIII. fig. 14, 15; and Milne Edwards, Sur les Ascidies, loc. cit. p. 41, Pl. VII. fig. 1, 16. This last-mentioned author has also observed that, with Cellanella (Ibid, p. 9. Pl. II.), these canals terminate in canals which communicate with the cavity of the body, and are extended into digiform prolongations upon the extremity of the peritonal sac, and herein the blood moves alternately up and down. The ramified canals which abundantly traverse the mantle of Phallusia, are, according to authors, real blood-vessels; see Cuvier, loc. cit. p. 16, Pl. III. fig. 1; Savigny, loc. cit. p. 162, Pl. IX. fig. 1, B, and Delle Chiò, Descriz. &c. III. p. 35, Tav. LXXXIV. fig. 2.

According to Kaulike (Ueber das Vorkommen der Holzbläserei im Thierreich, loc. cit.), these multiforme vessels which come directly from the heart and whose extremities are penicillated, appear to be continuous directly beneath the skin with other vessels returning by the course of these arterics.

90 Queen was the first to notice this analogy of the circulation of the Brachiopoda with the extra vascular vase of other Ascidia; see his Lettre sur l'Appareil de la circulation chez les Molusques de la Classe des Brachiopodes (Ann. des Sc. Nat. III. 1815, p. 315, Pl. IV., or Frariére's note No. 750).

90 For the arrangement of this part of the circulatory system, see Poli, loc. cit. Tab. IX. fig. 12 (Quin). Tab. XII. fig. 5 (Solen); Tab. XXI. fig. 10 (Spondylus); Tab. XXVII. fig. 8, 12 (Pecten); Tab. XXIX. fig. 7, 8 (Ostrea); Tab. XXXI. fig. 8, 9 (Mytilus), and Tab. XXXVIII. XXXIX. (Pinna). Also Bajouan, in the 1st, 1819, p. 42, Taf. I. II. (Audadonta); Trexierous, H. d. Zoot. u. Physiol. p. 44, fig. 67. 69 (Mytilus and Audadonta); and Garner, Trans. of the Zool. Soc. 1822, p. 98, Pl. XIX. fig. 4 (Pectes). An arrangement quite different from this type is found with Arca, whose two ariules are attached to the two widely-separated ventricles, and send out on each side an anterior and posterior aorta, which meet and join upon the dorsal median line; see Poi, loc. cit. Taf. XXV. fig. 2. 3. 5.

This system of lacunae forms, especially in the mantle, a beautiful net-work of delicate canals which, with the Nodae, are visible to the naked eye. It should not, however, be confounded with another net-work more difficult to be seen, and which probably constitutes a system of aquiferous canals, which is easily seen in the mantle, foot and other parts of the body by inflation. Delle Chiò has called it Rete lymphatico-vasculosum,

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* [§ 192, note 10.] See also Deshayes, loc. cit. p. 63, 64, &c., Pl. VIII. fig. 1, 2, 3, and Quatre-
fages, loc. cit. p. 47, Pl. I. fig. 7 (Teredo).—Bu.
lacunae situated at the base of the branchiae, and into which it thence passes.

CHAPTER VII.

RESPIRATORY SYSTEM.

§ 193.

With all the Acephala, the blood, just before returning to the heart, passes through a branchial, or distinctly respiratory organ, which, either simple or multiple in structure, is always hidden in the cavity of the mantle. The renewal of water takes place by special openings of the body, or through the slits of the mantle, which are often prolonged into two respiratory tubes. One of these openings is for the ingress, and the other for the egress of the water, and their currents carry in and out, respectively, food and faeces. In the cavity of the mantle, the water circulates in a definite direction and passes over the branchiae by means of the cilia covering their external surface.

§ 194.

The Branchiae of the Acephala are formed after four different types:—

1. With Salpa, there is one only of these organs which stretches, from above downwards and from before backwards, across the cavity of the body. The water enters through an anterior orifice which is usually valvular, and is expelled through a posterior opening by the contractions of the body. The branchia itself, which, near the heart, is bent a little in front at its lower posterior extremity, consists of a narrow band having upon one of its sides numerous transverse, thickly-set folds. Its remaining portion is flat, or the lateral borders are rolled up like tubes. The branchial vessels are ramified in the interior, communicating, at the superior extremity and has figured it very beautifully; see his Description, &c.; Tav. LXXV. fig. 6, and Tab. VI. fig. 1, 2 (Mantle of Pecten and Solen), Tav. LXXXIX. fig. 11 (foot of a Mastro).

The vascular network which Poli (loc. cit. Tab. XXXVIII.) has figured in the mantle of a Pinna, is probably only one of aquiferous canals. I shall again (§ 196) allude to this confusion between the blood and aquiferous vessels.

1 These respiratory motions aid also for the locomotion of Salpa; for, when water escapes by the posterior orifice, the animal closes the valve of the anterior one, so that the body is thrown forwards. On this account the cavity of the body is often called natatory.

2 See Cuvier, and Savigny, loc. cit.
3 Salpa costata, and maxima.
4 Salpa pinnata, cylindrica, octofora. When the branchia is contained in a tube it has often been compared to a Trachea; see Savigny, loc. cit. Pl. XXIV.

* [* § 192, note 11.] This lacunal system is well-marked with Teredo according to Quatrefages, who denies that these animals have a proper venous system. The grounds of this conclusion are, that these lacunae are always filled by injecting the heart, and on the other hand, all the other lacunae and the arterial system beside may be filled by injecting through one lacuna; see Mémoire, loc. cit. p. 55. — B.
of the branchiae with those of the body, and at its opposite one with the heart. Externally, it is covered with large cilia.\(^5\)  

2. With the Ascidiae, the walls of the body are, for the most part, lined with a membranous branchial apparatus. In the place of respiratory orifices, there are, what are usually called an oral and an anal tube. By the first of these, the water containing food passes directly into that part of the cavity of the body which contains the branchial apparatus, and which is therefore called the respiratory cavity. By the second, this cavity is emptied of the refuse water containing feces.\(^6\)  

The branchial membrane, which, in some of the simple Ascidiae,\(^7\) forms numerous longitudinal folds extending entirely over the respiratory cavity, presents a trellis-like aspect with rectangular meshes.\(^8\) These meshes which form prominent lines, have often small fleshy papillae,\(^9\) and are always provided on each side with a row of very long cilia which produce regular currents of water.  

Two longitudinal sinuses pass off from the base of the respiratory cavity and ascend along its greater and lesser curvature even to the oral tube, where they intercommunicate by a circular canal. These sinuses send numerous transverse vessels into the branchial membrane, where they anastomose vertically and thus form a net-work corresponding to the trellis just mentioned.  

From the continual changes in the direction of the blood-currents it is impossible to determine which is the arterial and which the venous of these sinuses.\(^10\)  

3. With the Brachiopoda, the internal layer of the mantle serves as a branchia. The internal surface of the halves of this organ is occupied with a system of very apparent blood-canaals.  

With Terebratula, and Orbicula, there are four large canals upon the surface corresponding to the imperforate valve, and two upon the other surface. These arise from two hearts, and are subdivided into numerous minute branches. Parallel to these last, are others, smaller, and which appear to communicate with them on the borders of the mantle; perhaps they are the branchial arteries, while the larger canals are veins.\(^11\)  

With Lingula, the branchial vessels are contained in collar-like projections, giving the inner surface of the mantle a very peculiar aspect.\(^12\)  

4. In the cavity of the mantle with the Lamellibranchia, there are two pairs of branchiae, which, as four lamellae, embrace each side of the abdomen, and the foot.\(^13\) The water which bathes them comes in partly through an opening in the mantle, and partly by a particular respiratory orifice upon the border of the abdomen, or by the respiratory tube of the siphon. It passes out through the anal orifice, or by another tube of the siphon.\(^14\)  

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\(^5\) These ciliated organs were first described by *Meinert*, loc. cit. *p. 555.*  
\(^6\) With the compound Ascidiae, the arrangement is such that several individuals are disposed in a star-like manner about a cavity in which their anal tubes open.  
\(^7\) *Sycaria microcosmus, momus, &c.*  
\(^8\) See the figures of *Savigny*, and *Milne Edwards*, loc. cit.  
\(^9\) *Phallusia sulcata, monachus, intestinales, and Dramma violacea;* see *Savigny*, loc. cit. *p. 194.*  
\(^11\) *Gower*, loc. cit.  
\(^12\) See *Cuvier, Owen, and Fogg*, loc. cit.  
\(^13\) The two external branchial lamellae are usually a little smaller than the two internal; and this difference is well marked with *Cardium*. According to *Valenciennes* (Comp. Rend. XX. p. 1688, XXI. p. 511), there is only a single pair of branchiae with *Lamina jamaicensis*, and *Columbella*, *Cy- theria tigrina*, *Tellina crusae*, and *Solen radi- atus*. In this last species, they consist only of two narrow, longitudinal swellings.  
\(^14\) The ingress and egress of the water through
These four branchial lamellae, whose lower border is free while the other is attached to the viscera, always extend along the abdomen, and not infrequently come together above. Each lamella is formed, essentially, by a widely-projecting cutaneous fold, the two leaves of which are connected by numerous transverse septa, to which correspond externally as many furrows which pass from the base of the branchia to its borders. All these furrows have upon each margin a row of long cilia, which, upon the borders of the branchia, connect with an ordinary ciliated epithelium. The compartiments formed by these interlaced septa are also lined with a very delicate ciliated epithelium, and connect with the cavity of the mantle at the base of the branchia.

With an entire group of this order, the branchial structure is quite different from that just described. Externally, these organs appear like ordinary branchiae, but examined more closely it will be found, that, instead of lamellae, they are composed of numerous thickly-set ribands arranged in rows. These ribands are formed of two lamellae blended together at their extremity. Their circumscribing space is without doubt solely for the lodging of the branchial vessels; for, at their base, there is no orifice analogous to those found in the other species of this order. The blood collects at the base of the branchiae in the longitudinal canal, from which the lateral vessels are given off, at right angles. Thence it passes into the branchiae, traversing a trellis-like net-work quite resembling the analogous one of the Ascidiae. Another series of lateral vessels serves as the branchial veins, pouring the blood into other longitudinal canals, whence it passes into the two auricles of the heart.

The different orifices of the mantle may be clearly seen by observing these animals, when they, at rest, protrude between the valves either their spins or the borders of the mantle and ting the surrounding water with coloring matter, which makes the currents quite distinct.

With Unio, Anodonta, Mactra, Cardium, Isocardia, Lutraria, &c., the four branchial layers are united at their posterior extremity. But with Pecten, Mytilus, Arca, Pectenula, and Pinna, they are disconnected and extended backwards by two free prolongations.

If these effuory movements tend to carry the water, with the internal branchiae, towards their free border; and with the external, towards their base.

These orifices of the branchial compartments are easily seen at the base of these organs; excepting, however, those belonging to the two external branchiae, which are concealed beneath a kind of canal formed by the mantle. These two canals, closed in front, open behind between the end of the abdomen and the anus into that portion of the cavity of the mantle leading to the anal fissure or tube, and which may be regarded as a Choca; see Unio, Anodonta, Venus, Cardium, Isocardia, Mactra, &c. With many, as for instance with Unio, and Anodonta, the compartiments of the external branchiae are much more developed than those of the internal, and their orifices can be closed in a lip-like manner by the vesicular enlargement of the septa which limit them on each side. With Pinna, the branchiae are quite different. Their leaves are united by short filaments instead of by septa; and thus, although not divided into compartments, there are orifices at their base which lead into the interior, and which are situated upon the internal surface of the internal, and upon the external surface of the external branchiae.

18 This pectinated form of the branchiae has been observed by Rer (Meckel's Arch. 1830, p. 349), with Mytilus, and by Meckel (System. d. vergleich. Annt. VI. p. 60), with Spandulys, Pecten, and Arca; see also, de Coste, and the Règne animal de Coste, nov. éd. Molinier. PL. LXXIV. fig. 2 a. I have seen similar branchiae with Pectenula, Astaca, and Lithodomus. Philipp (Wiegmann's Arch. 1855, I. p. 274) has seen them even more developed with Sturna magna.

This peculiar branchial apparatus with Mytilus has been described with much detail by Sharpey (Cyclop. d. Anat. I. p. 621). I have myself, during the autumn of 1847, completely verified the statements of this author, upon living specimens of the genera Mytilus, Arca, and Pecten, and would insist here only on a single remarkable fact. Each riband-like branchial filament has, upon both of its surfaces, several cap-like papillae by means of which these filaments are united together in a trellis-like manner. When the branchiae are forcibly distended, the papillae of the filaments are separated from each other. But this separation is not very extended, for there is a cord composed of delicate fibres, between each two papillae and binding them together; but sometimes, from undue force, this cord is broken in its middle, and then each broken extremity appears as a bundle of moving vibratile cilia which projects from the cavity of the capsule (see Sharpey, loc. cit. fig. 205, E, a). The function of this apparatus, which comes to be visible when the papillae are united together, is yet wholly doubtful.

19 Unio, Anodonta, Lima, Pinna, Ostrea, &c.; see Treindrns, Bicchiach; Arch. d. Zoot. &c. fig. 63, 65 (Ostrea and Anodonta); and Pelt, loc. cit. Tab. IX. fig. 17 (Unio).

20 For the branchial vessels, see, especially, Bo-
It now remains to speak of a particular system of canals traversing in all directions the body of the Lamellibranchia, which as yet has been called the aquiferous system, because it is supposed to serve for an internal respiration like that of the tracheae of insects. But, in the first place, the existence itself of such a system has been denied, although there are certain facts in its favor.

When one of these animals is suddenly taken from the water, numerous fine jets of water are seen to pass from these organs while the animal is withdrawing its foot and the borders of the mantle within the shell. From this fact it is evident that these orifices connect with aqueous reservoirs. But these openings are very small and probably are closely contracted, for they cannot be discovered either before or after the jetting out of the water. Orifices of this kind have as yet been found in a few species only; such are those in the extremity of the foot of Solen, and that singular tube found above the pedunculate anus of Pinna.

The aquiferous canals themselves are not very apparent, being seen only after injection. This last is easily performed by blowing through a small tube inserted under the skin. There will then be seen a very beautiful network of canals, which, nearly all of the same size, are spread out under almost the whole skin and enter the interior of the body by larger canals. These canals appear to be without walls, and have, in general, the aspect of simple lacunae traversing the parenchyma of different parts of the body.

By some naturalists, this net-work of canals is regarded as a system of lacunae circulating the blood; but when they are inflated, another net-work of vessels fills up the lacunae.
work of much smaller canals is seen expanded between and above them, and which can be only the blood-canals that were already visible before inflation. But the existence with these animals of a double system of lacunae having this interpretation, is attended with many difficulties. For then it must be admitted that one of these systems contains only water, and the other blood; and it is difficult to understand how two kinds of wall-less canals can traverse the body without passing into each other. But then, on the other hand, if the aquiferous canals are regarded as veins, and the other canals as arteries, how can this be reconciled with the fact that, in this case, the blood system would open externally and the blood escape through the natural orifices, while the water would be mixed with it from passing into the body? At all events, this portion of the organization of these animals still requires a more thorough investigation.

CHAPTER VIII.

ORGANS OF SECRETION.

§ 196.

The relations of the mantle to the secretion of the shell-substance and the byssus-forming organ, have already been spoken of. It now only

1) has given very beautiful figures of the aquiferous system of the mantle and foot of Pecten, Pinna, Solen and Maenius, but has regarded it as a Rete lymphatico-vasculosum. Milne Edwards (Comp. Rend. XX. p. 271, or Ann. d. Sc. Nat. III. 1845, p. 300, or Froriep's neue Not. No. 733, p. 96), who has seen these canals in Pinna, Maenius, Ostrea, &c., regarded them simply as a system of lacunae common to all the Acephala.

6 I have seen it thus, at least with Unio, and Anodonta.

7 Delle Chiome (Descr. &c. III. p. 53) thinks that, with the Lamellibranchia, the sanguineous system opens externally through special orifices.

8 [§ 196, note 1.] The means by which the Teredina penetrate the woody or stony substances in which they live, have received some investigation of late, and I refer here to the subject from its alleged anatomical relations.

According to Hancock (Proceed. Brit. Assoc. for the Advancement of Sc. 1848, or Ann. of Nat. Hist. 1848, II. p. 225, Pl. VIII. or Sillitoe's Amer. Journ. of Sc. 1849, VII. p. 285), "on a minute examination of the surface of the foot of Teredo Nereis it is found under the microscope to be crowded with minute brilliant points which, on being compressed, consist of comparatively large crystalline bodies imbedded within them. These crystals are numerous and of various sizes and shapes, chiefly five and six sided, but not by any means regularly so. They all agree in having one or more elevated points near the centre. These bodies are highly refractive, and are for the most part pretty regularly distributed over the whole convex surface of the foot, but are occasionally congregated in masses." This author thinks that this, as also all other boring Molusks, excavate by means of these parts which rasps down the substance to be removed. See as corroborative of these views, Clark Ann. Nat. Hist. 1859, V. p. 6. But naturalists are not agreed on this point, and however it may be with Teredo, yet with Pholas, other observers have failed to find these rasping particles in question; see a report on the discussion of Hancock's paper in the Athenaeum No. 1060; also Quatrefages, Mémorial sur le Genre Turrit, Ann. d. Sc. Nat. 1849, XI. p. 53, and History of British Molusca by Forbes and Hanley, p. 195.

After all, it would seem that it is most probable that this process is effected by the action of chisels.
remains to notice a very remarkable organ found in all the Lamellibranchia, and known as the Gland of Bojanus.

This organ, undoubtedly of a renal nature, is always double, and consists of a large long sac with glandular walls, and of a dirty-yellow or dark-green color. It is situated each side of the back between the pericardium and the inferior adductor muscle, and extends usually upon the sides of the abdomen to the base of the branchiæ.

Quite often these glands are united upon the median line of the back— their cavities being separated only by a thin septum. They communicate with the cavity of the mantle by two small openings which have swollen borders and are situated sometimes at the upper, and sometimes at the lower end of the sac.(5)

The usually very thin walls of these two sacs have numerous folds or plicae, which form compartments or areolæ, all of which are covered with a very delicate ciliated epithelium. The parenchyma of these walls is composed of a very loose tissue, which, upon the least disturbance, separates into small granular cells.(5) Most of these cells contain a blue-black round nucleus, to which is due the more or less deep color of these organs.(6)

With Unio, and Anodonta, these orifices are at the superior extremity of the renal sacs close beside the two genital openings; see Bojanus, Isis, 1819, p. 49, Tab. I. fig. 1; Bauer, in Müller's Arch. 1830, p. 310, Tab. VII. fig. 1, 2; Pfeiffer, Naturgesch. deutsch. Land-und Staatswasser-Mollusken, Abh. II. Tab. II. fig. 19, b.; and Neumyler, in the Neue Denkschr. VI. p. 22, Tab. I. II. They lie in the angle formed by the abdomen and the internal branchiae, and concealed beneath the internal leaf of these last. They had already been observed by Poli (loc. cit. i. p. 6, Tab. IX. fig. 13, i. 1.), who, however, did not recognize their true nature.

With Pecten, and Spondylus, these renal sacs, which are situated in front of the adductor muscle, have their two orifices at the lower extremity; see Garner, Trans. of the Zoöl. Soc. loc. cit. PI. XIX. fig. 2.; (Pecten).

With many, the genital organs open into the urinary ones. This is so according to Garner (loc. cit. p. 92), with Tellina, Cardium, Mactra, Phasianus, and Mytilus. I have very distinctly seen with Pinnaria nobilis, the two orifices common to the kidney, and genital organs. Their borders were swollen, and they were situated upon the anterior surface of the dorsal wall a little in front of the posterior adductor muscle. They opened into a very large sac with thin walls which had no glandular structure except at their lower extremity near the principal adductor muscle; see Poli, loc. cit. Tab. XXXII. fig. 2.; D.

The genital orifices open into the two sacs directly from these external orifices. With Mytilus edulis, the kidneys have a yet more singular arrangement; their two sacs situated at the base of the branchiæ are open their whole length, so that by spreading apart the branchiæ, the compartments and cells of these glands can be distinctly seen; see Trevisanus. Beobacht. aus d. Zool. u. Phys. p. 51, fig. 69, b.

It is only recently that the intimate structure of these organs was known. Neumyler was quite mistaken in regarding them as two testicles (loc. cit. p. 22). He speaks of tubes in which he affirms that he has seen spermatic particles, but he gives neither a detailed description nor a figure of one or the other. I have never been able to find anything of this kind in the Lamellibranchia. If the walls of these organs are prepared in any way for microscopic examination, a part of their parenchyma separates into a vesicular-granular mass, the particles of which have a very lively dancing motion. The muscles are due to portions of ciliated epithelium adhering to the cells and granules. It is in this way, probably, that Neumyler has been deceived, taking these moving bodies for spermatic particles.

These round nuclei, usually of a deep brown or blue color, can easily be seen in the kidneys of Unio, Anodonta, and Cyclos; but with the young individuals their number and size are quite limited, making the kidneys very pale. They resemble, moreover, perfectly the bodies contained in the renal substance of the Gasteropoda (see below). This analogy is particularly striking with Aspergilium nasijferum, whose renal sacs are triangular and situated between the heart and the extremity of the rectum, thus resembling in all respects the kidneys of the Gasteropoda, although Leuckart has taken them for the liver (Neone, wirh- halsgras Tabere B. Roth. Mem. loc. cit. p. 46, Tab. XII. fig. 6, p. 7.).
§ 197. THE ACEPHALA.

These nuclei are very solid and ought to be regarded as the secreting bodies. They are sometimes so large as to be visible to the naked eye as inorganic concretions, and, as they contain uric acid, they may well be compared to renal calculi. The walls of these kidneys are surrounded by a distinct net-work which arises from the large venous reservoir in which the afferent blood of the body is accumulated. A small portion of the blood which circulates in the kidneys passes directly to the heart; but the rest is emptied into the pulmonary arteries.

CHAP.ER IX.

ORGANS OF GENERATION.

§ 197.

The Acephala throughout, propagate by genital organs. With the Tunicata only, is there also observed multiplication by genumation.

This occurs with the compound and some of the simple Ascidiae, which remind one of the Zoophytes and more particularly the Polyps, which they resemble from other conditions of the organization. The buds are always developed at the lower extremity of the body, appearing first as small pyriform projections, covered by the general envelope of the mantle, into which the circulation is prolonged.

Gradually, an Ascidian is developed upon the round summit of this projection, while its peduncle is lengthened and somewhat constricted; this continues until the body of the new individual is entirely separated from

5 Similar concretions had already been seen and described with several of the Loomilibranchia by Poli, who has regarded the kidneys as organs for the secretion of the lime of the shell; see his classic work, Introductio, p. 19, also Tom. II, p. 86, Tab. XX, fig. 4, 6, k, fig. 12, 13 (Cytherea ehis), p. 143, Tab. XXVI, fig. 11, 12, 13, y. (Pectenculus plicatus), and p. 241, Tab. XXXVII, fig. 5, 6, 3, D (Pinnula nobilis).

These concretions were irregular and of a red or yellow color. I have recently found, in several individuals of Pectenculus plicatus, amber-colored concretions, mostly round, of variable size, giving these two organs the appearance of a fish's ovary filled with eggs. Having collected a considerable quantity of these concretions, I sent a part of them to Herr Von Babi of this city, who has favored me with their qualitative analysis. The result was that those with a conchoidal fracture were composed principally of phosphate of lime with a trace of magnesian phosphate, and a small quantity of organic matter which behaved with nitric acid exactly like uric acid. Notwithstanding Bojanus (Isis, 1819, p. 46, 1820, p. 404) has taken much pains to prove that these organs are pulmonary, yet the view that they are kidneys has found most support (Treviranus, in Plictanmann's Zeit. Phys. I, p. 65, and Carus, Zoot. 1834, II. p. 636), aside from the fact of their containing uric acid (Gurner, Trans. of the Zool. Soc. loc. cit. p. 92, and Owen, Lect. on Comp. Anat. &c. p. 284), a point upon which I was not before satisfied.

The chemical composition of these concretions, however, satisfies me that these organs are truly kidneys.

6 This is the mode of circulation of the blood through the kidneys, according to Bojanus, loc. cit. But the opinion of Treviranus is different. According to him all the blood returning from the branchiae traverses the glans of Bojanus before reaching the heart (Beobacht. aus d. Zoot. &c. p. 49). As these organs are not easily banded, it will be difficult to determine this point positively by direct observation. It is only by following analogy that Bojanus' opinion can be probable in its essential point, — which is, that if the glans of Bojanus are the analogues of the venous appendages of the Cephalopoda, and of which I am persuaded, and Vann der Hooven (Meeckel's Arch. 1828, p. 502) is the case, then they connect with the veins which go to the branchiae, and not with the arteries which go from the branchiae to the heart. The blood-current in the glans of Bojanus, therefore, ought to pass towards the branchiae and not towards the heart.
that of the parent, and the envelope of the mantle alone is common to both.\(^1\)

\[\text{§ 198.}\]

With the Acephala, the sexes are sometimes separate, sometimes united in one individual. But the genital organs are very fully developed, and, as with the Zoophytes, consist of an ovary and a testicle with an excretory duct; but in none are there copulatory organs, or uterine reservoirs for the eggs.

The eggs are usually spherical, rarely pyriform or elliptical. The pale yellow or reddish vitellus is finely granular, and surrounded with a vitelline membrane and a smooth colorless chorion.

The germinal vesicle has usually two nucleoli cemented together. Often there is a layer of white substance interposed between the chorion and the vitelline membrane.\(^1\)

The sperm is milky, and, at the epoch of procreation, quite full of very active spermatic particles. These always consist of an oblong, oval, or pyriform body, to which is abruptly attached a delicate tail, whose motions are not affected by the water in which these animals live.\(^2\)

With the Acephala of separate sexes, the ovaries and testicles so closely resemble each other, not only as to their form and the arrangement of excretory ducts, but also as to their locality in the body, that they are with difficulty distinguished each from the other, except at the period of procreation.

The copulatory organs being absent, here, as with the Zoophytes, the water is the fertilizing medium.

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\(^1\) This multiplication by buds has been observed by Milne Edwards with Batryllus, Polyplacanum, Amaranthium, Didemnum, and Perophora. It occurs also, undoubtedly, with other compound Ascidiae, and is the cause of the increase of the Ascidian-stock with the colonies of these animals. With the simple Ascidiae — Clavelina lepadiformis, and producta, the buds take the form of simple (Stolones), and the new individuals are separated from their parents with the separation of the mantle; see Milne Edwards, Sur les Ascidies compexes, loc. cit. p. 41, Pl. III. fig. 2. (Amaranthium proliformum), Pl. VII. 1, 19. (Batryllides rotiferum), and Pl. II. fig. 3 (Clavelina). Egerhardt (Nov. Act. Acad. Loop. Carol. XI. p. 263, Tab. XXXVI. fig. 1, &c.) has also observed these stolons upon a simple Ascidian.

\(^2\) These eggs have been figured by Wagner, Prodanus, &c., p. 7, Tab. I. fig. 5; Carne, Erfunzungsstafel, &c., Hist. v. Taf. I. fig. 2; and Nov. Act. Acad. Leop. Carol. loc. cit. p. 26, Tab. I. (Ammans and Unio), and by Milne Edwards, Sur les Ascid. comp. p. 25, Pl. IV. fig. 1-3 (Amaranthium).
The genital organs of *Salpa* are yet quite imperfectly known. They cannot be found except at the procreative period, and in a very few species only Ovaries have been discovered.

These consist of two flexuous zigzag cords, situated each side of the median line of the back, between the mantle and peritoneum. Sometimes they are prominent from their violet color.\(^1\) The young are always developed near the nucleus, in a cavity circumscribed by the peritoneum, but it is yet not determined whether it communicates with the ovaries by an oviduct, and whether it has distinct walls, so as to be comparable to an uterus.

As to the Male genital organs, we are yet in almost complete want of reliable researches.

From a single observation, it would appear that there is a testicle concealed in the nucleus, between the coils of the intestine, and communicating near the anus, with the cavity of the body.\(^2\) But this still leaves it uncertain whether these animals are hermaphrodites or of separate sexes.\(^3\)

The Ascidiae are evidently hermaphrodites, for the male and female organs, varying as to number and position, are found upon one and the same individual between the walls of the muscular and branchial sacs.

With the compound forms, as well as with many of the simple ones, the long, compact and usually yellowish ovarian mass is situated at the base of the cavity of the body. From this there arises a large thin-walled oviduct lined with ciliated epithelium, which ascends along the rectum towards the anal tube and opens into the cloaca through a papilla. Along its side and often beneath it, there is another long mass, which is evidently, from its contents, a testicle. It has a narrow and very tortuous *Vas deferens* filled with sperm, which runs parallel with the oviduct to its very extremity.\(^4\) *Cynthia* presents a remarkable exception in this respect. The gen-

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1. These two ovaries have been most thoroughly observed with *Salpa pinnata*, see Forskal, Descrip., in atimare orn. obserr, p. 13, Tab. XXVII. B, ii., 4; Cuvier, loc. cit. p. 12, fig. 1, 2, 6; Chamoso, loc. cit. p. 6, fig. 1; *Delle Chioie*, Mon. &c. III. Tab. LXXIV. fig. 8, h.; Meyen, loc. cit. p. 299, Tab. XXVII. fig. 1, 21, f.; and the Catal. of the Phys. Series, &c. I. PL VI. fig. 1-4, p. Cuvier (loc. cit. p. 22, fig. 9) has also observed two ovaries with *Salpa cylindrica*. It must also be added here that, according to Forskal and Chamoso, there are two violet ovaries, with *Salpa pinnata* both in a simple and an aggregated form.

2. It was *Krohn* (loc. cit. p. 52) who recognized with *Salpa maxima* a round testicle in the centre of the nucleus. It was composed of numerous seminiform delicate canals filled with a white semiliuid, and opening by a short canal into the uterine cavity. This testicle is probably the same organ that *Delle Chioie* (Descrip. &c. III. Tab. LXXVIII. fig. 4, d.) has described as an ovary. The assertion of Meyen, on the other hand (loc. cit. p. 357, Tab. XXVIII. fig. 5-10), that a conical organ which, with *Salpa mucronata*, is situated in front of the cervical ganglion, belongs to the male genital organs, is unfounded and certainly incorrect. But the observation of Krohn, on the contrary, gives support to the opinion of *Delle Chioie* (Mem. &c. III. p. 62, and Descrip. &c. III. 42) that this testicle canal which, with *Salpa pinnata*, lies along the intestinal canal, is a *Vas deferens*.\(^5\)

3. At all events, the question needs careful examination, whether both the simple and the compound forms of *Salpa* have male organs, or only one of them. In this last case, these animals would have some resemblance to the *Apleides*. Sars (loc. cit. p. 77) having declared that the solitary individuals of *Salpa* are sexless, then the aggregate individuals ought to be considered as representing the perfect state of these animals; but as yet neither this author, nor Krohn (Fromier's neue Notiz. XL. p. 151, and Ann. d. Sc. Nat. 1846, VI. p. 110) have been able to show the existence of ovaries in these animals. At least these two naturalists pass in silence the violet ovarian sacs of *Salpa*, mentioned by other observers.

4. Cuvier and Savinzy have known, and often figured the female organs of the Asciidae. Those of both sexes have been figured by Milne Edwards (Observ. sur les Ascid. comp. p. 21, PL Ill. fig. 1, 2, II. fig. 1, 3) with *Clavelina*, *Amaronaeum*, and *Polycelis*. The testicle of *Phallusia* and *Rhopalophia* is quite peculiar. It consists of a white multiformis canal widely spread over the hepatic layer of the intestinal canal; while the ovary always lies in a loop of the intestine; see *Delle Chioie*, Memor. Ill. p. 192, Tab. XLV. fig. 16, l., and Descrip. &c. III. p. 27, Tab. LXXVII. fig. 1, LXXXIV. fig. 3, l. (Phallusia intestinale and
ital organs are situated upon both sides of the body between the branchial membrane and the muscular wall with which they are intimately blended. They form, sometimes several round or angular projections divided into two groups, and sometimes four long crests whose four distinct secretory ducts open, after a short course, into the space included between the branchial membrane and the muscular sac, at a variable distance from the anal tube. (5)

With the Brachiopoda, ovaries only have as yet been found. These surround the liver, and stretch upon both valves of the mantle around the minute branches of the branchial vessels. (6)

With the Lamellibranchia, there are both hermaphrodites and separate sexes. But the last are much the more common; for the first have as yet been confined to Cyclas, (7) Pecten, (8) and Clavagella. (9) The testicles and ovaries lie directly behind each other on each side of the body, between the liver, intestine, and kidney. Their excretory ducts have not yet been satisfactorily made out; all that has been observed, is, that with Cyclas, the eggs pass between the lamellae of the base of the external branchial, and, being here developed, produce sac-like swellings. (10)

With those species which are of separate sexes, (11) the two ovaries or testicles are situated usually in the sub-hepatic region of the abdomen.
They surround the coils of the intestine, and often ascend along the back, covering the liver with their folds. Their excretory ducts are lined with ciliated epithelium, and open each side of the bottom of the abdomen through a fissure with smaller borders, communicating either with the cavity of the mantle close by the renal opening, or with the renal sacs. With those species which have a very small abdomen, these organs are spread out by numerous ramifications into the substance of both halves of the mantle.

The two external branchiae serve, for the most part, the function of an uterus; for the eggs, having escaped from the oviduct, are lodged in their compartments, and, by the aid of the cilia covering the cavity of the mantle, receive the sperm which is introduced in the water for respiration. The quantity of eggs thus accumulated is so great, that with Anodonta these organs are extraordinarily enlarged during the development of the young; and on this account the shells of the females of this genus are more convex than those of the males. In this way the sexes of these Naiades can be quickly distinguished from each other by the shell alone.

Most of the Acepheala undergo during their development, which always begins by a complete segmentation of the vitellus, a metamorphosis which is quite remarkable in many respects.

Among the Tunicata, the embryology of the Ascidiae is the best known. An oval embryo follows upon the segmented vitellus, and is quickly changed into a Cercaria-like larva. The tail is not formed from a gradual and therefore considered the Naiades as hermaphrodites.  

12 The genital and urinary openings are contiguous with the Naiades; see above § 196, note 3, and Neumann, Des Anodontarum et Unionum ovi divitu. Diss. Regiomont. 1827. This is the same also with Tachyna; see Van Beneden Am. Acad. Sci. Nat. VII. 1837, p. 129. With Pinna nobilis, I have found the genital orifice close behind those of the renal sacs. According to Garve (loc. cit. p. 92), a similar arrangement exists with Tellina, Cardium, Mactra, Paphus, Mys, and Pecten. The two genital orifices which Valenciennes (Arch. du Mus. &c. i. PL. II. fig. 5) and Delle Chiuse (Descr. &c. III. Tav. X.C. fig. 2) have seen at the lower end of the abdomen of Panagurata and Solen, belong probably also to the urinary system.

13 Mytilus (Poli, loc. cit. II. p. 202; Tab. XXXI. fig. 5). Anamia, Hatella, Mollinda, and Lithoboma (Garver, loc. cit. p. 97). With Lithoboma dactyulus, I have, however, always found the abdomen filled with testicular or ovarian masses.

14 It is with the Naiades that the branchiae as reservoirs of eggs, are best known; see Poli, loc. cit. I. p. 5; Tab. IX. fig. 18: Pfeffer, loc. cit. Arch. Allg. H. p. 11; Tab. II. fig. 16–19; Carus, Nov. Act. Acad. &c. p. 17; Tab. I. fig. 8; and Neumüller, loc. cit. p. 15, Tab. III. fig. 14 (Unio and Anodonta). While remaining in the compartments of the branchiae the eggs are slightly glued together. With Unio, they often escape through the anal fissures under the form of oval discs shaped like the branchial compartments. For a long time it was inexplicable how the eggs should always pass exclusively into the external branchiae, when the cavities of the internal ones were so much nearer the genital orifices. But Reer (Mecsek's Arch, 1830, p. 333) has shown that their route is circumvent; they glide along the base of the internal branchia to the cloaca, then ascend by a special canal of the mantle and pass into the external branchiae. This course is the more easily understood from the ciliated structure of these organs. Will (Prorup's neue Not. No. 327, p. 51) affirms that with Tellina the sperm of the male is evacuated in an analogous manner through the anal tube, and being there taken up by the females through their respiratory tube is conducted to the external branchiae.

I have also found embryos within the branchiae of Teredo navalis.

15 At present, these differences in the convexity of the valves appears to me to exist only with Anodonta (Wiegmann's Arch. 1837, p. 415); but Kirtland (Ibid. 1836, p. 126) has succeeded very well in distinguishing, by this character, the males and females of Unio, of North America.

1 The complete segmentation of the vitellus has been observed by Milne Edwards (Sur les Ascid. &c. p. 90, Pl. IV. fig. 1–4) with the eggs of Anodonta.

2 These Cercaria-like foetuses had already been observed in the Proceed. Amer. Assoc. Advancem. of Soc. 5th meeting, Cincinnati, 1851, p. 83. I have examined this subject with some care by the microscope, and have satisfied myself from an analysis of the contents of the organs that the genera in question are of separate sexes. — Ed.
ual elongation of the posterior part of the body of the embryo, but is produced by the fusion of a series of globules which result from the vitelline segmentation. These globules lie upon the surface of the embryo and, in their separation from it, assume a tail-like body which is folded in front, and only latterly is extended out behind. With some of the compound forms, it forms also two eye-specks upon the back of the larva. At this period of development the eggs are still in the cloaca, or perhaps have been discharged through the anal tube. Subsequently, the embryos rupture their shell, and then swim freely about by means of their very active tails.

Soon after this, the larvae are completely surrounded by a transparent structureless envelope, which ultimately becomes the mantle. They are then fixed by their anterior extremity, — lose their tail and assume their adult form.

With the compound forms, before the larvae have become fixed and deprived of their tails, numerous button-like prolongations arise from the anterior extremity and extend into the mantle; these, after the fixation of the embryo, are changed into as many individuals.

The development of the Salpæae has yet been incompletely observed, for its earlier conditions have received no attention. But the later ones present very curious phenomena.

In the first place, it is quite remarkable that the two forms of these animals which are always viviparous, produce young wholly dissimilar. The solitary individuals produce others joined together in a chain-like manner, while these last give rise again to the solitary forms. But in neither case do the embryos undergo a metamorphosis. This chain of individuals is usually composed of two rows joined together by several cords and enveloped in a common membranous tube. The individuals at the anterior extremity of this tube are the more developed, — there being a gradation in this respect to the posterior extremity, where they appear only as simple punctiform bodies. This tube usually surrounds also the nucleus of the parent, into the cavity of whose body its anterior extremity often widely

observed by Savigny (Mem. &c. Pl. XI. fig. 2), Pl. XXI. fig. 11) with Clavelina and Botryllus.

Subsequently they have been described by Audouin and Milne Edwards (Ann. d. Sci. Nat. XV. 1828, p. 119; Sars, Beskrivelser, &c., p. 69, Fig. XI.), and . globell (Edinb. new Philos. Journ. Jan. 1829, p. 155). Lately Milne Edwards (Sur les Ascidies, &c., loc. cit.) has furnished an exact embryology of these Ascidians, but which has been completed by Van Beneden (Mem. sur lesbray, l'amant, et la physique des Ascid., loc. cit.), and by Kolliker (Über das Vorkommen der Holzfaser im Thiereich, loc. cit.).

[Additional note.] The memoirs cited above have since been published, that of Van Beneden in Mem. de l'Écoud. de Bruxell. XX. 1847, Pl. II. and III.; that of Kolliker in Ann. d. Sci. Nat. V. 1846, 217, Pl. VII.

4 For the development of a simple Ascidian, see Dalyell, loc. cit.

5 According to Milne Edwards (loc. cit. p. 59), these animals use these processes like suckers to fix themselves. But this is contradicted by the observations of Kolliker, and Van Beneden.

6 This mode of propagation first described by Chaunisso (loc. cit.), has been doubted by Eschricht, who thinks that the young Salpæae produce solitary foetuses, while those of a more advanced age produce the aggregated form. But, as Steuerhau (Über den Generationswechsel, p. 50), has justly observed, there is no observation to support this view.

The alternate generation of the Salpæae, as first described by Chaunisso, has been confirmed in all particulars by Sars, and Krohn (loc. cit.). It is however, singular that, according to Krohn, the single egg of the aggregate Salpæa is formed in an ovary, while the whole development of these same animals when solitary occurs from an internal germination.

[1300 note 5.] The embryology of the Ascidiae has been followed out by Agassiz (Proc. Amer. Soc. for the Advancement, of Sci. 24 meeting, 1849, Cambridge, p. 157), and by Krohn (Muller's Arch. 1852, p. 312). The observations of Agassiz are complete throughout, but unfortunately not yet all published; the published portion (loc. cit.) refers more particularly to the formation and intimate structure of the egg. These of Krohn are chiefly confirmatory of those of Edwards and other observers above mentioned. — End.
extends, while its opposite end appears attached near the nucleus to the dorsal portion of the walls of the body.\(^{(5)}\)

The solitary individuals, which are produced by the chain-like forms, are also developed near the nucleus, and adhere quite singularly to the dorsal wall of the parent by a peduncle resembling an umbilical cord. These pedunculated embryos are always few in number, and have a proper vitellus. Often, however, there is only one.\(^{(6)}\) It may be questioned, moreover, if these eggs are not gradually developed with their peduncle at their place of incubation, or whether they become fixed at this place after having been developed in, and separated from the ovary. At least, one might almost think that, after all, this is only an internal gnammaton.

With the Lamellibranchia, the Naundes particularly, are those whose embryology has been observed. When the vitellus begins to segment, there are two superficial contiguous vitelline cells that do not participate in this process.\(^{(9)}\) These are gradually changed into two three-sided valves, while the remaining portion of the vitellus is transformed into a round embryo covered with cilia, which turns upon itself in the egg — being partly enveloped by the valves.\(^{(10)}\) This rotary movement, however, soon ceases, and the embryo divides itself into halves, each covered by a valve.\(^{(11)}\)

Each of these valves has a ciliated mouth near the hinge, and a proper intestinal canal.\(^{(12)}\)

In the middle of the angle formed by these halves is raised a short, hollow cylinder, — the byssus-forming organ, and out of which projects a very long transparent byssus.\(^{(13)}\)

\(^{(5)}\) See the figures of Chamoso, loc. cit., of Quoy and Gaimard (Ann. d. Sc. Nat. X. 1829, p. 226, Pl. VIII. fig. 5-6, and Voyage de l'Astrolabe loc. cit.), of Delile Chiege (Descr. &c. III, p. 42, Tav. LXVII. fig. 1); and especially those of Kielhreich (loc. cit. p. 53, Tab. I. II. IV. V.).

\(^{(6)}\) See Chamoso, loc. cit. fig. 1, D. 1, J. (Salpa pinnata, with a very developed foetus), fig. 3, F. (Salpa zavoria with three button-like foetuses little developed), Quoy and Gaimard, Isis, 1836, Taf. VI. fig. 12 (Salpa pinnata, with a very large foetus), and Ann. d. Sc. Nat., loc. cit. Pl. VIII. fig. 7-9 (Salpa microstroma, with four button-like foetuses); Megon, loc. cit. p. 350, Tab. XXVIII. fig. 9-10 (Salpa pinnata), Tab. XXVIII. fig. 1, A. (Salpa mucronata), Tab. XXIX. fig. 1. B. (Salpa antorctica), fig. 3-4 (Salpa maxima); Kielhreich, loc. cit. p. 63, fig. 27, p. 36 (an individual from the chain of Salpa cardiformis containing five, isolated, pedunculated foetuses; perhaps here should be mentioned the five pedunculated bodies which he (p. 39, fig. 18, p. 23) has described and figured with Salpa zavoria); finally Delile Chiege, Descr. &c. loc. cit. Tav. LXVII. fig. 3, (Salpa maxima, with a pedunculated body), and fig. 8, 13, (Salpa scultigeria, with a developed foetus).

\(^{(7)}\) There may be easily distinguished with Unio and Unio, a clear nucleus in each segmented division of the vitellus. Curru (Nov. Act. Acad. p. 43, Tab. II. fig. 1, 5, 16, 11) has seen the vitelline cells undulate, but he thought that the eggs, which contain the foetated cells out of which are ultimately formed the valves, were diseased and dead.

\(^{(8)}\) This rotation of the embryo of mollusks has already excited the astonishment of Lsewenzech (Genet., Ann. Nat. 1830). The cause was explained in a very unsatisfactory manner by Home (Philos. Trans. 1857, pt. 1. p. 39, or in Heusinger's Zeitschr. für organische Physik. 1. p. 324), and by Carus (loc. cit. p. 27), for they did not know of the existence of cilia.

\(^{(10)}\) This division of the embryo with valves often lying entirely open, has perhaps led Raibell (Schriften der Naturhist. Soc. loc. cit. p. 165, Tab. X. fig. 5), and Jacobson (Observ. sur le developp. du coel d'un Mondeke ou Unio et des Anodontes dans leurs branches, An. d. Sc. Nat. XIV. 1835, p. 264, De Blainville's report upon this work) to regard the young of Naundes for parasites, under the name of Glisthodaim parasiticum. See also the works of Carus (loc. cit.), and of Quoy et Quoy (Sur la vie interbranchiale des petites Anodontes, Ann. d. Sc. Nat. IV. 1835, p. 283, 284, 356, p. 231, PL XIX.).

\(^{(11)}\) Loew informs us that the young of Modiola, and Kelli is are formed upon a wholly different type. Their two valves, which are only slightly separated, are overlapped by two lobes (as Mon- tie?) which are erected and provided with very active vibratile cilia; the young swim by means of these lobes (Arch. Skandian. Beitr. zur Natur- gesch. Th. I. p. 155, Taf. 1. fig. 9-11). I also have observed with Tereno nautica, the embryos swimming freely about by means of a foot-like organ which protrudes between the valves and presents an active ciliary movement.

\(^{(13)}\) Quoy et Quoy, loc. cit. Pl. XII. fig. 20.

\(^{(14)}\) Quoy et Quoy (loc. cit.) has figured with each embryo two byssus-organisms out of which projects a double byssus. I have been unable to observe this, and, like Carus, have always found a single byssus-organ with a single byssus.

It is quite remarkable that not only the Naundes, but also Lamellarbranchia also, have this byssus-organ when quite young. Thus in the young of Cyclas cornea, I have distinctly seen a hollow byssus-organ in the foot, and from which projected a long single byssus.

The embryos of Kelli are also byssus according to Loew (loc. cit.).
Internally, the embryonic halves have three tentacular, stiff points, whose bases are surrounded by collars.\(^{(14)}\)

Near the hinge a large muscle passes from one valve to the other; this, from convulsive contractions which occur from time to time, gradually approximates the valves, which are wide open when the young individual escapes from the egg. These valves are trigonal and slightly convex. One of their sides goes to form the hinge, while the two remaining, which are a little arched, unite at an angle opposite. With this angle is articulated a prolongation curved downwards and inwards, and whose convex side has several spines.\(^{(15)}\)

After their escape from the eggs, these embryos are held together by their entangled byssuses. Subsequently, when the adductor muscle has definitely closed the valves, the embryonic halves are blended together, probably by a new metamorphosis.*

\(^{14}\) Carus, loc. cit. Tab. IV. fig. 14.

\(^{15}\) See Rathke, Carus, and Quatrefages, loc. cit.

* [End of § 200.] For the embryology of the Acephala with almost a profuseness of detail, see Löven (Oversigt af Kongl. Vetenskaps-Acad. Förhandlinger, 5° Argangen, 1848, Stockholm, 1849, or its transl. into German in Mutter’s Arch. 1848, p. 531, or in Wiegmann’s Arch. 1849, p. 312). This observer has observed with care the formation of all the organs and their mutual embryonic relations; even the résumé is too lengthy to be here quoted. — Eu.
BOOK TENTH.

CEPHALOPHORA.

CLASSIFICATION.

§ 201.

The organization of the animals composing this class is quite dissimilar; and, as in the preceding class there were species which approached the Zoophytes, so here there are those which are scarcely above the Worms. Thus, it is a question whether the genus Sagitta, which is placed at the head of this class, is really in its right place, although all the attempts to place it in another group have furnished results no more satisfactory.

Then again, it may be objected that the name Cephalophora should have been given to a class composed of the Pteropoda, Heteropoda, and Gasteropoda, since it belongs equally well to Cephalopoda; but I have adopted it for the sole reason of being unable to find a better.*

The sub-order Apneusta with its two families Anangia and Angiophora, has been established by Killiker in opposition to the other Gasteropoda, which have distinct respiratory organs.* This division, composed of small and very interesting species, is the more admissible since it is based upon the anatomical structure of these animals; and also as the most recent investigations have shown that the term Phlebenterata used by Quatrefages, is improper.

ORDER I. PTEROPODA.

Animals with natatory organs composed of wing-like or fin-like cutaneous lobes, symmetrically arranged upon the two sides of the body.

1 Meckel (Syst. der vergleich. Anat.) has already used this word in the same way.
2 Killiker has communicated to me a yet unpublished work in which he has described, beside Flabellina and Polycentrum, three new genera of the inferior Gasteropoda, under the names of Acanthina, Lissosoma, and Rhodope. He has placed these, with those which Quatrefages has described under the name of Phlebenterata, in the division of Apneusta which he divides into two sections: 1. Angiophora, having a heart and rudimentary vascular system. 2. Anangia, without either heart or vessels.
§ 201.

**Family: Sagittina.**
Genus: Sagitta.

**Family: Hyaleacea.**
Genera: Hyalea, Cleodora, Cymbulia, Tiedemannia, Cuvieria, Crescis, Limacina.

**Family: Clioidea.**
Genera: Clio, Pneumodermon, Spongiobranchae.

**ORDER II. HETEROPODA.**

Animals whose locomotion is performed by a carinated natatory apparatus situated under the abdomen and provided often with a sucker.

Genera: Phyllirhoë, Pterotrachea, Carinaria, Atlanta.

**ORDER III. GASTEROPODA.**

Animals which creep by means of a muscular disc situated under the body.

**SUB-ORDER I. APNEUSTA.**

Without distinct respiratory organs, and without a shell.

**Family: Anangia.**
Genera: Rhodope, Pelta, Actaeon, Actaeonia, Lissasoma, Chalidis, Flabella, Zephyrina, Amphorina.

**Family: Angiophora.**
Genera: Tergipes, Venilia (Protonotus), Calliopea, Eolidina, Aeolis (Eolidia).

**SUB-ORDER II. HETEROBRANCHIA.**

The branchiae inserted more or less freely upon various parts of the body. Sometimes there is a very simple patelliform shell.

**Family: Nudibranchia.**
Genera: Scyllaea, Tritonia, Thetis, Doris, Polycera, Plocamophorus.

**Family: Inferobranchia.**
Genera: Diphyllidia, Phyllidia, Ancylius.

**Family: Cyclobranchia.**
Genera: Patella, Chiton.

**Family: Scutibranchia.**
Genera: Haliotis, Fissurella, Emarginula.
§ 201. THE CEPHALOPHORA.

FAMILY: TECTIBRANCHIA.
Genera: Gasteropteron, Umbrella, Doridium, Bulla, Bullaea, Aplysia, Notarchus, Dolabella, Pleurobranchus, Pleurobranchae.

SUB-ORDER III. TUBICOLAE.
Animals which are enclosed, together with their branchiae, in simple slightly curved or irregularly flexuous tubes.

FAMILY: CIRRIBRANCHIA.
Genus: Dentalium.

FAMILY: TUBULIBRANCHIA.
Genera: Vermetus, Magilus.

SUB-ORDER IV. PECTINIBRANCHIA.
Branchiae in a special cavity situated at the anterior part of the back. Shell regularly spiral.

FAMILY: SIGARETINA.
Genus: Sigaretus.

FAMILY: PURPURIFERA.
Genera: Buccinum, Harpa, Cassis, Purpura, Eburnea, Terebra.

FAMILY: CANALIFERA.
Genera: Murex, Struthiolaria, Tritonium, Turbinella, Fasciolaria.

FAMILY: ALATA.
Genera: Strombus, Rostellaria, Pterocera.

FAMILY: CERITHIACEA.
Genus: Cerithium.

FAMILY: VOLUTACEA.
Genera: Voluta, Oliva, Mitra.

FAMILY: INVOLUTA.
Genera: Cypraea, Ovula.

FAMILY: CONOIDEA.
Genus: Conus.

FAMILY: TROCHOIDEA.
Genera: Scalaria, Turbo, Trochus, Phasianella, Rotella, Littorina, Janthina.

FAMILY: NERITACEA.
Genera: Natica, Nerita.
Family: Potamophila.
Genera: Rissoa, Paludina, Ampullaria, Ceratodes, Valvata.

Sub-order V. Pulmonata.
Family: Amphipneusta.
Genus: Onchidium.
Family: Lymanaeacea.
Genera: Lymanus, Planorbus, Amphipeplea, Physa.
Family: Helicina.
Genera: Helix, Caracella, Succinea, Bulimus, Achatina, Clausilia.
Family: Limacina.
Genera: Limax, Arion, Testacella, Parmacella.
Family: Auriculacea.
Genus: Auricula.
Family: Operculata.
Genus: Cyclostoma.

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CHAPTER I.

CUTANEOUS SYSTEM.

§ 202.

The cutaneous envelope of the Cephalophora consists of a dense dermis, of a cellular structure, often containing pigment matter which is free or in cells. It is covered with a delicate ciliated epithelium, which, with
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THE CEPHALOPHORA.

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the aquatic species, is extended over nearly the whole body, but with those which are terrestrial, is confined to certain spots.\(^1\) With the Gasteropoda, its external surface is striated or tuberculated; on the whole, the skin of these animals closely resembles a mucous membrane and secretes constantly a large quantity of mucus.

It has an extraordinary contractility, due to a muscular layer intimately blended in its texture.

With many species, the skin forms around the neck or back a fold, which is usually circular; the posterior or the upper part of this fold is dilated into a hernial sack containing a portion of the viscera. This portion of the skin is called the mantle.\(^2\) With many, it can be wholly withdrawn into the body, and then the orifice of the fold acts as a siphon.\(^3\)

§ 203.

Very many of the Cephalophora carry upon their back a univalve shell\(^4\) which is formed by the border and external surface of the mantle, and, in a few cases only, in its interior.\(^5\)

The border of the mantle is the tissue most concerned in the formation of the shell. The shell's increase depends upon it, and for this purpose it is always in contact with the orifice.

With the majority of the terrestrial Gasteropoda,\(^6\) the completed shell has a lip at its orifice, which, in some aquatic species,\(^7\) is repeated several times at regular intervals during the development. In many Pectinibranchia, the border of the mantle has prolongations, which also secrete lime and produce around the orifice of the shell wing-like or spinous processes.\(^8\) With many species of this sub-order, one of these processes has a kind of canal, called the Siphon, which conducts the water into the respiratory cavity. With some, this siphon is contained in an appendix to the orifice of the shell,\(^9\) while, with others, it is protruded through a fissural opening of this last.\(^10\)

With some Gasteropoda, the mantle is folded over a large portion of the external surface of the shell, which it covers with a calcareous substance.\(^11\)

The borders of the mantle have numerous, short, glandular follicles, whose walls are composed of large cells, some of which contain a finely-granular

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1 Ciliated epithelium covers the entire surface of the body with Lymnocer, Planorbis, Physa, Paludina, Volutes, Terpizes, Flabellina, and Polygona. With the terrestrial Gasteropoda, I have found it only on the surface of the foot, and with Arion, upon also the borders of this organ, which is separated from the rest of the body by a longitudinal furrow. I cannot, therefore, support the assertion of Valentin (Wagner's Handarb. erbasch der Physiol. I. p. 429) that with Helix and Limax, the whole surface of the body and even the tentacles are covered with this epithelium.

2 With Limax, Arion, and some allied genera, this mantle is quite rudimentary,—covering like a shield only a small portion of the back.

3 The genus Sagitta differs, in this respect, from all the other Cephalopora. Its skin is without folds, forms a kind of cylinder, and consists of a dense dermis perfectly smooth and non-contractile. At first, its structure appears to be homogeneous, but a more careful examination shows extremely delicate parallel fibres running from before backwards in uninterrupted and apparently varicose rows; they resemble nuclear fibres of Hente.

4 With Chiton, exceptionally, the shell is formed of several intricated pieces so united as to be movable. In some species the organic so much exceeds the calcareous substance, that the shell has a horny aspect, as with Hipasus, Hyplea, and Cenidora. With Cymbiola, the shell is even cartilaginous; that of Cypraea, on the contrary, is composed almost exclusively of lime,—the quantity of organic substance being very small.

5 With Bulina, Limax, and Testacea, the shell is wholly concealed in the mantle. With Arion, the line secreted in the interior does not unite with the shell, but forms a mass of loosely juxtaposed granulations.

6 With the Auriculae, and many of the Helicina.

7 Murax, Harpa, Scalaria.

8 Strombus, Pterocera, Mures.

9 Cerithium, Murax, Rosselaria, Turbinella, Fasciolaria.

10 Harpa, Oliva, Volutes, Buccinia, Dolium. Cowan.

11 Ovula, Cypraea.
substance (carbonate of lime) which effervesces with acids, while the others enclose pigment granules. Calcareous cells are also found, but fewer, in the parts of the mantle covered by the shell. These portions of the mantle serve to increase the thickness of the shell, and to repair the loss of substance in places removed from the mantle-borders.

The intimate structure of the shells of these animals is much simpler than that of the Acephala. They are homogeneous throughout, and correspond to the internal layer of the Bivalvia. When the carbonate of lime has been extracted, the remaining organic base consists of a homogeneous membrane having numerous folds varying very much as to form and number, according to the genera.

This organic base is produced by the external surface and border of the mantle, in the form of a mucous liquid containing calcareous and pigment granules, and which, hardening, forms the successive layers of the shell. Usually there is no epidermis connecting the border of the mantle with the orifice of the shell; it can, therefore, together with the body of the animal, be drawn deeply into the shell. With some Gasteropoda, however, the shell is covered with a kind of epidermis, which has even hair-like processes.

Many of this same order have, upon the posterior dorsal surface of the foot, a peculiar plate, by which they can tightly close the opening of their shell after having withdrawn their bodies.

This plate, or operculum, composed, sometimes of concentric rings, and sometimes of lines spirally rolled together in the same plane, is composed of a calcareous, or a horny substance. In both cases its organic base is lamellated or plicated like that of the shell. The operculum (Operculum caducum) with which certain Helicina close their shell at the beginning of winter, is completely structureless, and without rings, spiral lines or lamellae.

Beside these external calcareous products, there are certain species of these animals, which have other deposits of the same nature inside the skin and in various parts of the body, which, in the form of needles, form superposed, reticulated masses.

9 See H. Meeke, Uber die Blattnsehen der Gartenschnecke, in Müller's Arch. 1844, p. 17.
10 According to Gray (Locul. Med. Osa, pt. V. 1857, 38, vol. I. p. 350), some Gasteropoda have, in the border of their mantle, numerous glands which secrete pigment matter; and the shell will be marked according as this secretion is continuous or irregular.
11 The only solid particles I have been able to find in this mucus are calcareous molecules which discharge gas when dissolved in acids.
12 In the shells of Helix, Bulinus, Cyclotoma, Patula, Natica, and Cyprea, I have also been unable to find the cellular structure which Bowerbank (Ann. of Nat. Hist. No. 65, 1843) afirms exist in those of several Gasteropoda.
13 Helix borussa, hispida, villosa, and the young of Patula vivipara.
14 With Patula vivipara, there are, between the cutaneous layers, numerous globular calcareous bodies formed of concentric lamellae; and with Limax, not only is there a calcareous plate in the mantle, but also a powder of the same nature scattered here and there in other parts of the skin. The white stripe which adorns the sides of the neck and foot of Helix are composed of short, cylindrical, thickly-set calcareous needles.

According to Kuhl, the entire skin of Palaeoera is crowded with analogous, but ramified needles.

Similar, probably, are the concretions which, with Terpsipes, are found everywhere beneath the skin (Nordmann, loc. cit. p. 9, Taf. III. fig. 4 a.), and the calcareous net-work found in the mantle and foot of several species of Doris (Lovén, 1848, 1842, p. 561, Taf. I. fig. 3.)
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THE CEPHALOPHORA.

CHAPTER II.

MUSCULAR SYSTEM AND ORGANS OF LOCOMOTION.

§ 204.

The muscles of the Cephalopora are composed of smooth, primitive bundles, which are easily separated into short oblong fragments, and often have numerous nuclei scattered through their substance.  

The cutaneous muscular system is highly developed; it consists of a muscular layer made up of oblique, longitudinal and transverse fibres, which are not divisible into separate muscles, and are intimately united with the skin. Upon the ventral surface, with the Gasteropoda, this cutaneous layer is very thick and forms a long disc, — the foot. The fibres of this foot, by contraction, produce wrinkles which succeed each other from behind forwards in a wave-like manner; by this means the whole foot glides easily over solid bodies or on the surface of the water. Many Gasteropoda use their foot for a sucker also, and there are circular, tendinous fibres inwoven between those of the muscle proper.

With the Heteropoda, there is, upon the ventral surface, a laterally compressed process which has numerous muscular fibres. These animals swim upon their back and use this as an organ of locomotion; while a sucker, situated upon its borders, is used, it is said, as an organ for attachment.

The Pteropoda, Thetis, and Aplysia, have, upon certain places of their body, wing-like expansions, which are traversed by numerous muscular fibres, and are used as oars for swimming.

The horizontal fins which are found have had various interpretations as to their nature, from the case with which they are detached (see Meckel in his programme: Additamenta ad historian Moluscorum, Peticum et Amphibirorum, Halae, 1832).

Rudolphi (Synopsis. Euct. p. 572), and Otto (Nov. Act. Nat. Cur. XI. p. 294, Tab. XLI. fig. 1, n-4) have taken them for parasites under the names of Phaenecius varis, and Pertinaxus thetidea.  

Delce Chiefo, who formerly described them under the name of Planaria occultata, has since concurred in the opinion of the last two naturalists; but he suggests that they may be the young of Thetis attached to the back of their parents to obtain nourishment; see his Memos. loc. cit. 1, p. 59, Tab. II. fig. 9-15, PI. p. 121.  

Although the true name of these appendages was made known long ago by Maceri (Atti della reale accademia delle scienze di Napoli. II. 1778, p. 150, Tab. IV.), yet it is only recently that it has been confirmed by Verani (Ibis, 1842, p. 252) and Krohln (Muller's Arch. 1842, p. 415).

1 Here again the genus Sagitta forms an exception. Its muscular fibres are distinctly striated, and its whole muscular system consists of a simple cutaneous layer composed only of longitudinal fibres.

2 The breadth of this foot varies much according to the species. With Selenloca, and Tritonia, it forms only a very narrow furrow, with which these animals can embrace marine algae.

3 Thus, with Patella and Hiatia.

4 See Forskoll, Icones, &c., Tab. XXIV. fig. A; Delce Chiefo, Memos. loc. cit. Tab. XLI. fig. 1, and Descriz. loc. cit. Tab. LXIII. — IV.; Quoy and Gaimard, in the Ann. d. Sci. Nat. XVI. 1829, PI. II. fig. 4-6, or in Tab. 1833, Tab. VI. (Pterotracka and Carinaria); and Xang, in Mi-an. de la Soc. d'Hist. Nat. de Paris, loc. cit. p. 375, PI. IX. fig. 1, 10, a. d. (Atlante).

5 See Eschriech, loc. cit. Tab. I. fig. 5 (Clio) and Van Beneden, Exercit. &c., Fasc. II. Pl. I. II. (Cymbutul and Tiedemannia). It is possible that Phetis uses as nutritary organs, beside its large cephalic fin, the contractile appendages which exist on each side of the back. These last are finely punctuated through their whole length. With Paludina, Helix, Bulimus, Conocella, Legidz found the essential element of this tissue to consist of a tube, formed by the fusion of cells linearly arranged; the nuclei of these cells were often visible.

My own observations on Nautilus heros agree with those of Legidz — that the essential structure is a fibre and not a fibrilla. — Eb.
upon various points of the body of Sagitta, differ from the locomotive organs of the other Pteropoda in being composed wholly of parallel, homogeneous fibres, which decrease in size from the base to the border of this organ, but which have not the least resemblance to those of muscle. 6

Some Pteropoda have tentacle-like processes situated in bundles about the mouth, which have a small sucker at their end; they are, therefore, probably used as organs of attachment. 6

§ 205.

Beside this cutaneous muscular system, the cavity of the body contains isolated muscles which serve different uses. With the turbinated Gasteropoda, a large muscle arises from the columnella, and, after dividing into many parts, is spread over the sides of the body to be inserted into the foot, and serves as its retractor. Several other muscles of variable size arise also from the columnella, and are distributed, some to the tentacles, and others to the pharynx and the penis — serving also as retractors of these organs. With the shell-less Cephalophora, the retractors of these various organs arise from the inner surface of the mantle, or from the foot. 6

CHAPTER III.

NERVOUS SYSTEM.

§ 206.

The central part of the nervous system of the Cephalophora consists of a group of closely approximated ganglia, connected together by several nerves filaments, and which surrounds, like a ring, the base of the pharynx or the oesophagus. This oesophageal ring may be divided into several portions; one situated above, one below, and one each side of the oesophagus. The portion lying above consists usually of two very large contiguous ganglia, which may be called the brain, since they furnish nerves to most of the organs of sense, — that is, the tactile organs, the eyes, and sometimes also the organs of hearing.

The portion lying below, varies much in its form and size. It consists, sometimes of a group of ganglia blended together, or circularly united by short connecting filaments, and sometimes of a simple transverse cord. The two lateral portions consist always of two cords connecting the upper and lower parts just mentioned. The lower portion, which sends nerves principally to the muscles of the foot and to several visceræ, is often asymmetrical. The peripherie nerves are always given off from the ganglia and never from the connecting cords, of the oesophageal ring.

6 See Krohn, loc. cit. p. 6.
7 See Cuvier, loc. cit. p. 8, Pl. 1. B. fig. 497.
8 (Pneumoder- = D'Orbigny, Voy. dans l'Amer. merid., tom. 1839, p. 867, Tab. 1. fig. 19. 1-15 (Spongianarachnien and Pneumoder-
om), and Eschricht, loc. cit. p. 3, Tab. 11. fig. 12. 13 (Clio).
9 For these isolated muscles, see Cuvier, Mem. sur la limace et colmaçon, loc. cit. p. 11, Pl. 11. fig. 2, 3.
§ 207.

The nervous system of the Cephalophora is enveloped by a very distinct fibrous neurolemma containing often various pigment, which, in some species, give it, and especially the ganglia, a well-marked color. The neurolemma enters the ganglia and forms there numerous septa which separate the ganglionic globules into groups. These are very distinct, and although of variable size, always contain a very large nucleus composed of obscure granules in the midst of which are seen usually two to four transparent nucleoli of unequal size.

These ganglionic globules are very often pedunculated, and then their very slender peduncles or processes usually extend far into the nerves which are given off from the ganglion, thus leading one to infer that these globules are the origin or termination of the nervous fibres. Moreover, these primitive fibres which traverse the ganglia, are always situated in that portion of them which is contiguous to the oesophagus or pharynx, while the opposite portion is occupied by the ganglionic globules.

§ 208.

There is a great variety in the form and arrangement of the different parts of the nervous centre, according to the orders and families, as follows.

1. The Heteropoda quite resemble the Lamellibranchia by their widely-separated ganglia connected by very long commissures: At the anterior extremity of their body, and above the oesophagus, there is a cerebral mass which sends backwards two long nervous cords, which, after passing along each side of the intestinal canal, terminate by entering the inferior ganglionic portion (Ganglion pedale), situated near the ventral surface. The cerebral portion furnishes nerves to the organs of sense, to the skin, and to the lips, while the posterior portion sends them chiefly to the foot, and to the muscles of the tail.

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1 These ganglia are orange-colored with Lamnacous, and red with Planorbis, Paludina, Hystricorhynchus.

2 Hanover (Recherch. microscop. sur le Systeme nerveux, 1844, p. 60, Pl. VIII.) has very well described and figured the ganglion-globes of Helix and Limax.

3 Judging from Ehrenberg's figure (Ueber die ganglion-globules of Ascian empiricorum, he was not aware of the large nuclei which they contained.

4 See Helmholtz, De fabr. Syst. nerv. evert. loc. cit. p. 19; Hanover, loc. cit. and Will, in Muter's Arch. 1844, p. 76.

5 For the descriptions and figures of the nervous system of several Cephalophora, see Cuvier, Mem. loc. cit.; Garner, Trans. of the Lin. Soc. XVII. p. 483; Rymer Jones, Cyclop. of Anim. p. 392; Art. Gasteropoda; Anderson, Hist. III. p. 606; Art. Nervous System; and van Beneden, Excursus edd. loc. cit.


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* [§ 207, note 4] Leidy's results, after very careful dissection, do not accord with these, for he observed none of the nerve-fibres originate or terminate in the ganglionic globules; see loc. cit. vol. I. p. 248. — Ed.

1 [§ 208, note 1.] See also Alder and Hancock, loc. cit. Part. II. Pl. II. fig. 9 (Dendronotus); Pl. IV. fig. 16 (Doto); Part. III. Pl. VIII. fig. 8 (Eolithes); Part. IV. Pl. V. fig. 1, k. (Scyladactis); Part V. Pl. II. fig. 13 (Doris); Pl. XLIII. fig. 10 (Antiope); then Leydig, Ueber Paludina vivi-para, &c., loc. cit. p. 152, Taf. XIII. fig. 49, a. β. (Paludina); Blanchard, Ann. d. Sc. Nat. XI. 1843, p. 78, Pl. III. fig. 1, Pl. IV. fig. 1 (Januaus); Middendorff, loc. cit. p. 75, Taf. IX. (Chiton); Leidy, loc. cit. Pl. I. fig. 11-14 (Limax), Pl. IV. fig. V. 15-17 (Fagrinus); Pl. V. fig. 1.32, 33, 34 (Boylmus); Pl. VI. fig. II. 25, Pl. VII. fig. VIII. 20, Pl. IX. fig. IV. 26, 27, Pl. X. fig. IV. 24, 25, 26 (Helix); Pl. XII. fig. IV. (Helicina), Pl. XIV. fig. IV. Pl. XVI. (Glandina). — Ed.
The nervous centre of the genus Sagitta is in many respects like that of the Heteropoda. A hexagonal cerebral ganglion lies upon the upper surface of the oesophagus; another quite large is situated in the centre of the ventral surface of the trunk. These intercommunicate by two large, very long cords. The cerebral ganglion gives off two pairs of nerves; — of these the anterior are distributed to the base of the oral hooks, and the posterior to the organs of vision; each sends, internally, a filament which passes backwards and joins at the middle of the posterior part of the head with the one from the opposite side, thus forming a loop. The ventral ganglion sends off backwards two considerable, diverging nerves, from whose external surface pass off numerous, delicate, cutaneous filaments.

2. With some Tectibranchia, a simple cerebral ganglion above, and two others, quite widely separated, below, are, all three, connected together by as many cords, thus forming a large oesophageal ring.

3. With many Pteropoda the cerebral ganglia are wanting, while the lower portion is highly developed. This last is composed of two or three pairs of ganglia blended together, and from which passes off a simple commissure embracing the oesophagus.

4. With very many of the Apneusta and Nudibranchia, as also with several other Heterobranchia, the cerebral mass is highly developed, while the remaining part of the oesophageal ring consists of a simple nervous cord. The two or four cerebral ganglia are either connected by transverse commissures, or intimately blended together.

* * *

p. 99, Tav. LXIII. (Carinaria). Pterotrochaea has a similar disposition. According to Delle Chiuse (loc. cit. Tav. LXIII. fig. 14, Tav. LXIV. fig. 11), a short commissure arising from the cerebral ganglionic mass,等情况，in a ring-like manner, the oesophagus of Carinaria and Pterotrocha; but this is not mentioned by either Cuvier, or Milne Edwards.

3. See Krohn, loc. cit. p. 12, fig. 2, 5, 13.

4. With Aphyllia, according to Cuvier, Mem. loc. cit. p. 22, Pl. III. IV., and with Pterotrochaea, according to Delle Chiuse, Mem. loc. cit. Tav. XLII. fig. 8, 6. v. I have found the oesophageal ring arranged in the same way with Pterotrechacea.

5. This form is found especially in those species where the eyes and tentacles are abortive or entirely wanting; see van Beneden, Exercices zo6. Fasc. II. (Hydrea, Tiedemannia, Cleodora, Cuvieria, Luminaea, and Cymbulia). Probably to the absence of these organs is due, with the Pterotrecha, the often confusing of the dorsal with the ventral surface. It is, moreover, interesting that, among the Gastropoda, Chiton, which is without eyes and tentacles, has a transversal row of six sub-oesophageal ganglia, but no cerebral ganglia; see Cuvier, Garner, and Rymer Jones, loc. cit. For the nervous system of the Pteropoda, see also Boldrini, Comp. rend. XVII. No. 11; or Frossin's note Nov. XXXVIII. p. 84.

6. With Baltha, Dendrura, and Phyllidia, there are two cerebral ganglia united by a more or less long commissure; while with Tritonia, and Scyphaea, there are four united by short commissures; see Cuvier, loc. cit. With Aptothis, the cerebral mass is also composed of four ganglia transversely arranged (Delle Chiuse, Descriz. loc. cit. Tav. LXXXVIII. fig. 12, 15, and Hensen and Embliche, loc. cit. PL V. fig. 16). With Eolidia, Zephyrina, Amphora, Pelta, and Chelidina, there are two pairs of fused ganglia which are connected together by a delicate commissure (Quattrogugli, Ann. d. Sc. Nat. XIX. 1853, p. 26. Pl. XI. fig. 5, 4. L. 1844, Pl. VI. fig. 3-4). With Thetis, and Doris, on the other hand, the brain is a simple mass, of considerable size, and situated in the neck (Cuvier, loc. cit.);

Nerve lobulato to borders of the mouth (Taf. IX. fig. 6, 5). — Ed.

† [§ 208, note 5.] Middendorf (loc. cit. p. 79) has described with Chiton a flat and almost perpendicularly nervous band situated on the internal splinter of the mouth, and which he thinks is probably two ganglia cerebralis fused together (Taf. IX. fig. 6, 5); this band sends off numerous nerves lobulato to borders of the mouth (Taf. IX. fig. 6, 5). — Ed.

‡ [§ 208, note 6.] Blanchard (Ann. d. Sc. Nat. XI. 1849, p. 78) describes the central nervous system of Janus (Eolidia) as consisting of six medullary masses arranged around the oesophagus, — the cerebral, the cervical and the pedal ganglia; see his figures, Pl. III. fig. 1, and Pl. IV. fig. 1. For the Cephalic nervous system of the Nudibranchia, see Adler and Hanocck, loc. cit. Parts II. II. fig. 9 (Dendronotus, Doto), cerebral ganglia, four, and give off ten pairs of nerves; Part III. Pl. VIII. fig. 3 (Eolida), cerebral ganglia, four, and give off twelve pairs of nerves; Part IV. Pl. V. fig. 13 (Eumenia), cerebral ganglia, four, and give
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5. With other Ampnoeust, the cesophageal ring is composed of several contiguous ganglia which closely bind the cesophagus, but have no apparent commissures. 7

6. The other Gasteropoda, and especially the Pectinibranchia and Pulmonata, have a highly-developed superior and inferior ganglionic mass; the cesophageal ring is formed by these ganglia, being connected on each side by a cord, which is often double than single. 8 The superior mass is composed usually of two ganglia which are connected by a transverse commissure, or are contiguous, and sometimes even blended together. 9

The inferior mass also presents many variations. With some species it consists of a circle of distinct ganglia, connected by commissures; 10 while with others, it is composed of a group of ganglia more or less fused together. 11

§ 209.

With many of the Cephalophora, 12 there is a Splanchnic nervous system. This can be divided into a Plexus splanchnicus anterior and posterior. The first is composed usually of a double Ganglion pharyngeum inferius, connected by a transverse commissure, or contiguous, but rarely blended together. They are situated under the cesophage and connect with the cerebral mass by two filaments; they send off nerves principally to the pharynx, to the cesophage and the salivary glands; and when the posterior plexus is wanting, they send nerves also to the liver and the genital glands. 5

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7 This cesophageal ring is composed of eight ganglia with Tergipes (Nordmann, loc. cit. p. 35, Tab. 11.), but with Acteon, there are only seven, the lower one of which, asymmetrical, sends two very long cords of communication to two large cerebral ganglia, while the two lateral ganglia connect by a short commissure passing under the cesophage (Jullien, loc. cit. p. 184, Pl. VII. fig. 1). According to a communication which Kolleber has made to me, this ring, with Flabellina, has only five ganglia. 8

8 See Berthold, in Malter's Arch. 1835, p. 378. 9

9 There is a transversal commissure between the two cerebral ganglia with Patella, Helix, Planorbi, Planiscella, Junitha, Turbo, Paludina, Lymnaea, Planorbi, and with many other species having a shell. These two ganglia are contiguous with Helix, Limax, and Cypraea; but they are fused into one with Buccinum, Martes, Olivai, Harpa, Volutes, and other Pectinibranchia. 10

10 Helix has two, and Patella four inferior ganglia disposed transversely, which send off from each side a double cord of communication to the brain. With Ancylus, Lymnaea, Planorbi, Physa, Succinea, Bulimai, the inferior portion is composed of five to seven ganglia, unequal and disposed asymmetrically, and connected together by off eight pairs of nerves; Part V. Pl. II. fig. 13 (Doris), cerebral ganglia, five pairs, and a single ganglion,—the pairs are symmetrically placed with regard to the median line and give off fifteen pairs of nerves; the single or viseral ganglion gives off four nerves which are distributed to the organs of reproduction, to the stomach, to the two hearts, and to the branchiae, and can be traced into ganglia of the sympathetic system belonging to these several organs; Part V. Pl. XLIII. fig. 10 (Antiope), cerebral ganglia, six, and give off ten or eleven pairs of nerves. 11

11 With all these genera, the cesophageal ring is formed by lateral commissures which unite with the sub-cesophageal ganglia which are sometimes two (Dendronotus, Doto, Euenecies), sometimes four (Eodos, Doris, Antiope). — Ed.

* [§ 209, note 11.] The nervous system of the terrestrial Gasteropoda has been most carefully described and beautifully figured by Leidy (loc. cit.). The details are so full that I can only indicate the work. — Ed.
The posterior plexus is composed of a single mass, rarely of two separate ganglia. It is situated under the digestive canal or between its coils, and from it pass off nerves to the intestine, the liver, and the genital glands, beside two cords of communication with the lower portion of the oesophageal ring. (*\(^2\))

**CHAPTER IV.**

**ORGANS OF SENSE.**

\(^\text{§ 210.}\)

The Tactile organs of the Cephalopora consist of two to four contractile tentacles situated upon the head, or the anterior part of the back.\(^1\) They receive nerves of considerable size from the cerebral mass, which have sometimes a ganglionic enlargement in the extremity of the tentacle.\(^2\) With some Gasteropoda these tentacles are hollow and button-like at their extremity, and can be inverted like the finger of a glove.\(^3\) But with the

\(^*\) \([\text{\textsection 209, note } 2]\) For the splanchnic nervous system of the terrestrial Gasteropoda, see \cite{Leidy}, loc. cit. \(\text{\textsection III. fig. IV. 2 (Helicina), \text{\textsection XIV. fig. IV. 3 (Glaudina), and \text{\textsection XVI. fig. II. 2 (Helix).}}\)

\(^{1}\) See also, for that of the Nudibranchia, \text{\textit{Ald-r}}

\(^{2}\) \text{(Cymbulia, Tiedemannia, Hyatea and Lima}

\(^{3}\) \text{The Plexus splanchnicus posterior with its two long cords of communication is quite apparent with Aplysia (see \text{\textit{Ochter}}, loc. cit. \(\text{\textsection II.}, \text{\textsection IV. fig. 1, L.)}. \text{\textit{Delle Chiaje (Memor. Tav. V. fig. 1, X. fig. 7, o, and XII. fig. 8, y, v.)}, has observed it with Doridium, and Pleurobranchus, beside the ganglia just mentioned, and in Pleuro-

\(^{4}\) \text{branchus, he found it composed of two entirely separated ganglia. \text{\textit{Van Beneden (Exerc. zoot. \text{\textsection I. p. 36, \text{\textsection I. fig. 5-3) has found it composed of only a single ganglion with Pneumoder-

\(^{5}\) \text{man. \text{\textit{Milde Edwards (loc. cit. \text{\textsection II.}, \text{\textsection XI. fig. 4, o, v, 0), has observed in the visceral sac of Carcinus, first, a double Gastrozoon abdomen, which receives two long cords of communication from the cerebral mass and from the Glaucophora pedele, and then a Glaucophora undecim, communicating with the two abdominal ganglia.}}\)

\(^{6}\) \text{There are most usually two tentacles, But with Limax, Arion, Helix, Achatina, Clausilia, and other Helicin., there are four. They are wholly wanting with Sazitta, Cleonora, Coviera, Hyatea, Pterotrichia, Lissosoma, Rhodox, Physi-

\(^{7}\) \text{and Dendotrichia.}}\)

\(^{8}\) \text{This swelling exists not only with the inferior and cyclides tentacles, but also the superior ones bearing eyes, with several Limacina and Helicin. However, no ganglionic globules are seen in it, and only a finely-granular substance lies interposed between the primitive fibres.}}\)

\(^{9}\) \text{With the Limacina and Helicina, these organs are invested by a muscle which arises upon the esophagus or upon the internal surface of the mantle, and is inserted at the extremity of each tentacle.}}\)

\(^{10}\) \text{and Hancock, loc. cit. (\text{\textit{Eolie, Doris, Antio-

\(^{11}\) \text{pa, &c.})}. According to \text{\textit{Middendorf (loc. cit. \text{\textsection 76, Chit-

\(^{12}\) \text{ton has a complex splanchnic nervous system which is widely distributed over the digestive organs and their auxiliary glands. — Ed.}}\)
The organs of Hearing, which as yet have been found in all the orders of these animals, are, as in the Acepaha, of a very low order. Like them also they consist only of two simple round auditory capsules whose transparent, solid walls contain sometimes a single, sometimes several otolites, suspended in a clear liquid, and which are composed of carbonate of lime.\(^4\) When they have attempted to show the analogy of these organs with the auditory organs of the embryos of fishes (Wiegmann's Arch. 1841, I. p. 149, Ann. d. Sc. Nat. XIV. 1845, p. 195, Pl. II.), Kölükt (Ueber das Gehörgan der Molliusk en, in Fromrie's neue Not. XXV. 1845, p. 123) also has described them with many marine Heteropoda, and Gasteropoda, so that they may be said to exist in all the Cephalophora which have been subjected to dissection. The following are the genera in which they have been observed. Among the Pteropoda: Cymbulia, Tiedemannia, Hyalea, Crepis, Pneumoderon, Limacina; Heteropoda: Carinaria, Pterotricha, Phyllirhoe, Atlanta; Gasteropoda: Beladope, Flabellina, Lissasoma, Amphorina, Pelta, Chilidina, Zephyrina, Acteon, Antarelina, Auris, Pseud, Trigipes, Doris, Patreca, Tritonia, Theis, Diaphylidia, Anegus, Doridium, Apysia, Gasteropoter, Umbrella, Notarchus, Pleurobranchus, Pleurobranchaea, Paludina, Lymnaeus, Planorbis, Physa, Bullina, Clasrixia, Succinea, Helix, Arion, and Limax. It is remarkable that the auditory organs are developed so early, for they may be distinguished while the embryo is still in the egg. From the account of Pouget (Ann. d. Sc. Nat. X. 1838, p. 64), it appears that he saw the otolites in motion in an embryo of a Lymnaeus, but without knowing their nature. Loven also, who saw the two capsules in the young Gastropods (Kongl. Vetensk. Akad. Handl. 1839, p. 227, or Isis, 1842, p. 300, Taf. I. fig. 1, a) did not know what to think of them. F. Braeckel (Ann. d. Sc. Nat. XV. 1841, p. 127, Pl. I. fig. 13, 14, 17, d.) mistook them in the embryos of Limax and Aplysia, for nervous ganglia; while Allman (loc. cit. p. 153, Pl. VII. fig. 10-12, d.) regarded them as eyes in the embryos of Acteon. Sars (Wiegmann's Arch. 1841, I. p. 8, Taf. I. fig. 7-11) and Nordmann (loc. cit. p. 44, 57, Taf. IV. V.) on the other hand, very correctly recognized them as organs of hearing in the embryos of Doris, Tritonia, Tergipes, Beccium, Littorina, Cerithium, etc.

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majority of the Cephalophora, they are solid and usually conical, and sometimes are replaced by two groove-like, cutaneous processes, which, from contractions of their muscular fibres, can be shortened, but not inverted.\(^6\)

Beside these tentacles, many Cephalophora have also as tactile parts, organs, which consist of two contractile lobes situated on each side of the cutaneous fold which rests over the mouth like a second lip.\(^9\) The prehensile organs about the mouth of certain Pteropoda, and the contractile filaments and processes on the border of the mantle of other Cephalophora, are also used, probably, as tactile parts.\(^6\)

\[\text{§ 211.} \]

The organs of Hearing, which as yet have been found in all the orders of these animals, are, as in the Acepaha, of a very low order. Like them also they consist only of two simple round auditory capsules whose transparent, solid walls contain sometimes a single, sometimes several otolites, suspended in a clear liquid, and which are composed of carbonate of lime.\(^1\) When they have attempted to show the analogy of these organs with the auditory organs of the embryos of fishes (Wiegmann's Arch. 1841, I. p. 149, Ann. d. Sc. Nat. XIV. 1845, p. 195, Pl. II., B.) Kölükt (Ueber das Gehörgan der Molliusk en, in Fromrie's neue Not. XXV. 1845, p. 123) also has described them with many marine Heteropoda, and Gasteropoda, so that they may be said to exist in all the Cephalophora which have been subjected to dissection. The following are the genera in which they have been observed. Among the Pteropoda: Cymbulia, Tiedemannia, Hyalea, Crepis, Pneumoderon, Limacina; Heteropoda: Carinaria, Pterotricha, Phyllirhoe, Atlanta; Gasteropoda: Beladope, Flabellina, Lissasoma, Amphorina, Pelta, Chilidina, Zephyrina, Acteon, Antarelina, Auris, Pseud, Trigipes, Doris, Patreca, Tritonia, Theis, Diaphylidia, Anegus, Doridium, Apysia, Gasteropoter, Umbrella, Notarchus, Pleurobranchus, Pleurobranchaea, Paludina, Lymnaeus, Planorbis, Physa, Bullina, Clasrixia, Succinea, Helix, Arion, and Limax. It is remarkable that the auditory organs are developed so early, for they may be distinguished while the embryo is still in the egg. From the account of Pouget (Ann. d. Sc. Nat. X. 1838, p. 64), it appears that he saw the otolites in motion in an embryo of a Lymnaeus, but without knowing their nature. Loven also, who saw the two capsules in the young Gastropods (Kongl. Vetensk. Akad. Handl. 1839, p. 227, or Isis, 1842, p. 300, Taf. I. fig. 1, a) did not know what to think of them. F. Braeckel (Ann. d. Sc. Nat. XV. 1841, p. 127, Pl. I. fig. 13, 14, 17, d.) mistook them in the embryos of Limax and Aplysia, for nervous ganglia; while Allman (loc. cit. p. 153, Pl. VII. fig. 10-12, d.) regarded them as eyes in the embryos of Acteon. Sars (Wiegmann's Arch. 1841, I. p. 8, Taf. I. fig. 7-11) and Nordmann (loc. cit. p. 44, 57, Taf. IV. V.) on the other hand, very correctly recognized them as organs of hearing in the embryos of Doris, Tritonia, Tergipes, Beccium, Littorina, Cerithium, etc.

\[\text{See also Hancock (Ann. Nat. Hist. 1852, IX. p. 189) in this respect with the Bulbuls. In these no proper tentacles exist, as is well known, but this author shows that here the head-lobe, which is the result of the fusion of tentacles, is the seat of this sense.} \]

\[\text{— En.} \]
THE CEPHALOPOHRA. § 211.

single this otolite is spherical and crystalline, but when multiple they are fusiform, a little compressed, and usually very numerous, there being with some Gasteropoda, thirty or forty, and even eighty in each capsule. 4

The movements of these bodies are even more marked with the Cephalopoda than with the Aechopela; and the balancing and rotation of each, producing a kind of trembling of their whole mass which occupies the centre of the capsule, is a wonderful spectacle. It has been recently discovered that these motions are due to very small cilia upon the internal surface of the capsule. 5

The situation of these two auditory capsules varies according to the orders, families, and genera. With several Heteropoda, and Apneusta, they lie a little under the skin, behind the eyes, and are connected with the cerebral mass by a longer or shorter auditory nerve. 6 In some Nudi-branchia, they lie upon the cerebral mass itself, contiguous with the posterior part of the eyes. 7 With the other Cephalopoda, they are situated at the lower side of the body, and usually touch the inferior portion of the oesophageal ring. In only a very few of the genera are the two auditory nerves separated and distinct from each other. 8

Phasianella, and Rissoa. I have myself seen them quite early in the embryos of *Formolus.* 4

2 There is a single otolite only with the Hetero-

poda, the Tabulibranchia and several of the Ap-

neusta; see *Delle Chiinge, Deserix, &c.* II. p. 310,

Tav. LXIII. fig. 5, 6 (*Cunners*) and *Quatre-


8-10 (Jactea,) *Perla, Chelida.* According to

Kroeh's and my own observations, there are

groups of small fusiform otolites with some Pter-

oda, and very many of the Gasteropoda, as *Cy-

gnum,* *Hydor,* *Doris,* *Tritonia,* *Aeolis,* *Veni-

ula,* *Pleurobranchus,* *Paludina,* *Planorbis,* *Lym-

naeus,* *Helix,* *Liuna,* and many others. It

is not rare to find among these fusiform otolites,

others composed of two or four calcareous capsa-

cles. Those of a spherical or spindle shape divide,

from pressure, into four to eight fragments in the

direction of circular lines which may often be seen

before division. According to the observations

of Laurent, Kroeh, and myself, in the centre of

these bodies, a single otolite is first developed, in

the capsules which are to contain several, and others

are added as the embryo increases; see Frey, in

Freyc's neeut. XXXVII. No. 961, p. 122, and

Wiegemann's Arch. 1845, L. p. 217. Taf. IX.

3 A priori, it might have been inferred that these

motions are due to cilia, for the otolites never come

in contact with the sides of the capsule, but ab-

always remain at a little distance from it, and when

there are several, they are grouped in the centre;

indeed when one has strayed from this central po-

sition it is always quickly returned. Wagner

(Lehrbuch der Physiol, ed. II. 1845, p. 139) positively

affirms that he has seen cilia in these capsules. They

have been very distinctly seen by Kolthir likewise

(loc. cit.) with *Tritonia, Thetis,* *Pleuro-

branchus,* *Diphylidia,* *Hydor,* *Liuna,* and

Rhodope.

4 See Laurent, loc. cit. fig. 1-6, and *Quatre-

fazes, Ann. d. Sc. Nat. I. loc. cit. Pl. IV. VI. Af-

accord to *Delle Chiinge* (Deserix, &c., loc. cit. Tav.

LXIII. fig. 3, d. 14, f,) and *Mieke Edwards* (Ann. d. Sc. Nat. XVIII. 1842, Pl. XI. fig. 1, 2,

fig. 3, h.), the auditory nerves are very long with

*Carinaria.* With many Cephalopoda which are

transparent, the auditory organs may be perceived

by the naked eye, through the skin, as two white

spots; 5

6 Doris, *Thetis,* *Tritonia,* *Aeolis* (Kroeh, loc.

cit.), and *Terigipes* (Nordmann, loc. cit. p. 44,

Tab. 11.)

6 According to *Kroeh* (loc. cit. No. 394, p. 311)

the two auditory capsules of *Pleurobranchus,* and

*Paludina* receive distinct auditory nerves from the

inferior portion of the oesophageal ring. He has

observed the same with *Cygnum,* and *Hydor.*

(loc. cit. No. 396, p. 311); but Van Beneden (loc-

§ 211, note 2.) See, for the auditory apparatus

of *Aeolis, Hancock and Emblyton,* Ann. Nat.

Hist. 1849, 111. p. 196. The otolites which have

hitherto been regarded as calcareous, they banded not

to be materially affected by long treatment with

acetic acid. — Ed.
The organs of Vision are absent with only a very few genera of the Cephalophora. They are never more than two in number, and their size, compared to that of the body, is usually small; they are smallest with some Heterobranchia, and the largest with the Pectinibranchia.

The eyes consist usually of two round bulbs concealed under the skin; this last is colorless at this point, and lies over them like a thin lamella. Each bulb is limited outwardly by a tissue resembling a Scleroticosa, but beneath the skin, this tissue is more convex than elsewhere, and thus forms a kind of cornea. The sclerotic is lined by a dark pigment layer, or choroidosa, which, near the corner, ends in a free border, forming thus a Papilla. With some Gasteropoda, the papillary border has a very thick pigment layer which serves, perhaps, as an Iris.

The internal surface of the choroidosa is covered by a whitish pellicle which undoubtedly is a Retina, for the optic nerve enters the scleroticosa at a point opposite the cornea. The cavity of the eye-bulb is filled with a gelatinous, vitreous body, which, in front, envelops a spherical crystalline lens.

The Optic nerve arises from the cerebral ganglia, and runs along, for a longer or shorter distance, in company with the tentacular nerve of the same side.

**Cephalophora.**

1. *Pectinibranchia.* For the visual organs of *Paludina*, with histological details, and especially confirmatory of *Krohn*’s observations, see *Lepidir*, loc. cit., *Siebold* and *Kolker*’s *Zeitschr.* 1850, p. 159, Taf. XII. fig. 25, Taf. XIII. fig. 26-28.

2. *Krohn* (loc. cit. 1837, p. 482) affirms that he has seen this white layer with a *Paludina*.

3. The existence of a distinct vitreous body was known to *Swammerdam*, and has been confirmed by *Krohn* (loc. cit. 1837).

4. According to *Krohn* (loc. cit. 1839), the two optic nerves of *Paludina*, *Murex*, *Aplysia*, *Cypride*, and *Oxygenia*, are blind. In many of the Pteropoda, the auditory appear to have been taken for the ocular organs.

5. *Swammerdam* (Bibel der Nat., p. 47, Tab. IV. fig. 5-8) made out very correctly the structure of the eyes of *Helix*. The later works of *Meckel’s Beitr. Arch.* 1819, p. 259, Tab. V., *Horscht* (Beitr. zur Physiol. u. Naturgesch. 1824, p. 57, Taf. XI. fig. 8), and of *De Blainville* (De l’Organis. des Animaux, 1823, p. 44), upon the eyes of *Helix, Paludina,* and *Paluta*, have been much improved by those of *Muller* (*Meckel’s Arch.* p. 1829, p. 208, Taf. VI. fig. 4-8, and Ann. d. Sc. Nat. XII. 1851, p. 7, Taf. III. 184, or in the Iris, 1856, p. 247, Taf. VII.), and *Krohn* (*Muller’s Arch.* 1837, p. 479, 1839, p. 332, Taf. X. fig. 6-8) upon the eyes of *Helix, Murex, Paludina,* and *Pterocancha.*

6. The eyes of the *Helix* present a remarkable exception; their very convex cornea is surrounded by a collar of skin; the ocular bulb is very long, and, at its base, the scleroticosa spreads out interiorly and posteriorly, forming a round prominence; see *Muller’s Arch.* Ann. d. Sc. Nat. XVII. 1842, Taf. XI. fig. 1, c. (*Cunicaria*), and especially the description of *Krohn* (loc. cit. 1859) of the eye of *Pterocancha*. The ocular bulb of *Cito* is also very long, but has no prominence; see *Eschrlicht*, loc. cit. p. 7, Tab. XIII. fig. 20. Those of *Actarus* are long and pyriform; see *Quattrages*, Ann. d. Sc. Nat. 1844, Taf. VI. fig. 8, and *Altmann*, loc. cit. PI. VII. fig. 2.

7. A dark iris is distinctly seen with *Paludina* and *Murex*. That of *Strombus* is very brilliant and multicolored, according to *Quay* and *Guinard*; see *Voy. de l’Astrolabe*, Zool. III. p. 56, Molines, Pl. L. I. I am not yet certain whether or not the iris of these Gasteropoda is susceptible of movements of contraction and dilatation. It may be well to add that the choroidosa of the *Helix* has several spots of its surface free from pigment. 

8. *Krohn* (loc. cit. 1837), p. 482 affirms that he has seen this white layer with a *Paludina*. 

9. According to *Krohn* (loc. cit. 1839), the two optic nerves of *Paludina, Murex, Aplysia, Cyprie,* and *Oxygenia,*...
praeen, Rostellaria, Buccinum, and Littorina, arise from the cerebral ganglia by an origin which is distinct from that of the tentacular nerves. I have been able to confirm this for Helix, Limax, Caracolla. According to Müller (Ann. d. Sc. Nat. loc. cit. p. 12, Pt. III. fig. 6), the optic nerve is only a special branch of the end of the tentacular nerve.

The two pretty simple eyes of Sagitta, forming two prominences on the top of the head, are spherical, and rest directly upon the ganglionie enlargement of the optic nerve, see Krohn, loc. cit. p. 13, fig. 5, 14.

§ According to Quadratagena (loc. cit. I, p. 158, Pl. IV. fig. 6, 7), the eyes of Pelta, and Chalidus, have, instead of a choroida, a mass of pigment containing neither a sclerotic nor a cornea. According to the observations of Nordmann, and Kuhlker, the eyes of Terebrides and Polygoena are without optic nerves, and lie directly in contact with the cerebral ganglia. With Doris, Glauces, Thetis, Acolis, Doridium, Aplysia, Bulba, Bulma, &c., these organs are comparatively small and appear more or less distinct through the skin, sometimes in front of, and sometimes behind, the tentacles. §

§ This is so with various Heteropoda, all the Pulmonata, Pectinibranchia, and with some of the Heterobranchia; see Loven, loc. cit. and Isis, 1812, p. 361.

§ The eyes are situated at the base of the tentacles on a small prominence, with Carinaria, Atlanta, Fainacea, with the Lymnaacea, the Operculata, Patella, Enositra, Pisana, Siganetia, Paludina, Littorina. A kind of peduncle replaces this prominence with Holiotis, Nucicella, Phasianella, Trochus, Ceratodes, Amp Funcarides.

§ The prominences supporting the eyes are situated on the outer side of the tentacles with Buccinum, Harpa, Dolium, Cypraea, Murex, Oliva, Turbo; and at a variable distance from the extremity which they sometimes surpass in breadth and length, as, for example, with Strombus.

§ Amphiprionica, Helicula, and Limacina.

(1.) The eye at the extremity of the tentacle (Helix);

(2.) The eye at the internal base of the tentacle (Limacena);

(3.) The eye at the external base of the tentacle (Cypridona);

These organs present also three types as to their organization:

(1.) The lenticular crystalline lens, the vitreous humor fluid, non-adherent (Helix);

(2.) The lenticular crystalline lens, the vitreous humor thick and united to this last;

(3.) The crystalline lens thick and slightly convex, the vitreous humor viscous and slightly adherent to the lens.” — Ed.
CHAPTER V.

DIGESTIVE APPARATUS.

§ 213.

The highly-developed digestive organs of the Cephalophora always commence at the anterior extremity of the body, with a round, oral orifice, which is surrounded with tumid lips, but rarely has special prehensile organs. These lips are quite contractile, and can evert and invert the mouth; with many species, they can be prolonged into a cylindrical proboscis. The walls of the oral cavity are very muscular, and, with the majority of the species, form a round and often very large pharynx. The epithelium of this cavity is frequently developed into collars or callosities which serve as masticatory organs. With some Gasteropoda, this apparatus is composed of two horny, lamelliform jaws, which have a truncate, convex, internal border, and move upon each other in a lateral manner. These jaws are situated, sometimes directly behind the oral orifice, and sometimes at the base of the pharynx.

Many other Gasteropoda have only an upper jaw enclasped in the roof of the oral cavity, and which is easily seen from its deep-brown color. It consists of a transverse, semilunar, horny plate, upon whose anterior surface are several vertical crests, which terminate upon the free border by as many tooth-like processes.

Nearly all the Cephalophora have a longer or shorter fleshy mass, adhering to the base of the pharynx, and which is sometimes grooved longitudinally; it is quite comparable to a Tongue. Sometimes it is very large and contained in a membranous sheath at the base of the pharynx. It is always armed with horny, denticulated spines and plates, which are very delicate, and arranged in quite elegant, longitudinal and transverse rows. The

1 Such are the tentacular appendages which have a sucker, of Petrolopa (Clia, Spongiobranchaea, and Pneumodermon), already mentioned above (§ 204).

2 There is a retractile proboscis with Pneumodermon, Spongiobranchaea, Pterotrachea, Thetis, Buceinum, Dolium, Cypraea, Murex, Conus, Voluta, and many other Podiibranchia.

3 The external borders of these jaws are easily perceived between the lips, as with Scyllaena (Cuvier, Mem. loc. cit. fig. 6, a, 6, b), with Tritonia (Sauvage, Descr. de l'Egypte, Hist. Nat. II. Pl. II. fig. 1-10), and Delia Chiefe, Delia. loc. cit. Taf. XLII. fig. 1, and with Diphyllidia and Bulla. They are found also directly behind the lips with Venusia, Aceolina, Ampharina, and Perigipes (Alder, Hauckeck and Emberton, Ann. of Nat. Hist. XIII. p. 162, Pl. II. fig. 3, 4, XV. p. 4, Pl. II.; also Quatrefages, Ann. d. Sc. Nat. I. p. 147, Pl. V. fig. 5, and Nordmann, loc. cit. p. 12, Tab. I. fig. 7). With Dentalium, on the contrary, the jaws are situated at the base of the oral cavity (Deshayes, loc. cit. p. 353, Pl. XV. fig. 11, b, b. 15, 16, or in the Isis, 1854, p. 463, Tab. VI. fig. 15, 16, 20).

4 This upper jaw is particularly developed with the Limaces and Helicita; see Cuvier, Mem. loc. cit. Sur la Limace, etc., Pl. II. fig. 4 (Limax); Troschel, in Wiegmann's Arch. 1836, I. p. 297, Taf. IX. fig. 3-9 (Arion, Limax, Helix, Clausilia, and Succinea), and Erdt, in Mor. Wagner's Reisen in der Regensp. Algier. III. p. 268, Tab. XIII. XIV. With Lymnaeas and Planorbis, there are, beside, two small lateral jaws; these exist also with Patella, and Patina, where the upper jaw is wanting. With Zephyrula, there are also three jaws at the base of the pharynx; see Quatrefages, loc. cit. I. p. 132, Pl. V. fig. 1.8

8 [§ 213, note 4.] For many details upon the oral organs of the Helicina, of an anatomical as well as a zoological import, see Troschel (Ueber de Mundtheilc einiger Heliciten, in Wiegmann's Arch. 1849, p. 225). — Ed.
points of these spines turn backwards, and thus the retractor tongue can serve as an organ of ingestion, and as such is used with much address. (3)

§ 214.

The intestinal canal has often longitudinal folds and a ciliated epithelium extending from the oesophagus to the rectum, and even into the hepatic ducts. (3) It is usually two or three times the length of the body, and has therefore several convolutions, which, with the species which have a shell, are contained in its spiral cavity.

It commences at the base of the pharynx by an Oesophagus, of variable length, which is sometimes dilated at its posterior extremity into a kind of crop. (3)

The stomach, which, from constrictions, (6) is often divided into several portions, consists sometimes of a simple dilatation with thin walls, (3) and at other times of a nicely-defined cavity whose walls are thick and fleshy, (3) and provided, sometimes, with thick epithelium, and even, in certain cases, with plates and horny teeth. (3)

The cardiae and pyloric ori-
The intestine, having made more or less numerous convolutions, seldom forms a rectum, but opens, usually, close by the respiratory orifice on the right side of the anterior end of the body, and rarely at the posterior extremity. With the Pectinibranchia, the rectum often projects widely into the cavity of the mantle, as a longer or shorter prolongation upon whose extremity the anus is situated.

Sagitta and the Apneausta present wide differences from this just-described type of structure. With the first, the mouth opens into a short cesophagus which passes directly, without any stomachal dilatation, into the intestine; this last runs straight backwards, and, curving downwards, terminates in the anus situated on the median line of the ventral surface at the posterior end of the body.

With the Apneausta, on the other hand, there is a stomach with several and often highly-ramified caecal appendages—which, in some species, extend even into the dorsal appendages. A short rectum follows directly upon the stomach, and ends in an anus, often difficult to be found, and situated at the anterior part of the right side of the body.
With these Cephalopora which are nourished by solid food, and which often have, therefore, masticatory organs, there are, almost without exception, highly-developed Salivary organs. These are usually composed of two lobular yellow glands surrounding the oesophagus or stomach, and which have in front two excretory ducts which are lined with ciliated epithelium.\(^1\)

These ducts pass, in company with the esophagus, through the osphagial ring, and, extending over the base of the pharynx, end in the oral cavity on each side of the tongue. With some species, these glands consist of two very long tubes.\(^2\) Some Gasteropoda have two pairs of these organs, one of which opens at the anterior part of the mouth.\(^3\) In a few cases only these organs appear to be wholly wanting.\(^4\)

The Biliary organs are always present; and their glandular follicles contain hepatic cells filled with a brownish-yellow substance.\(^5\) Most commonly, the liver is large and distinctly separated from the digestive canal; and it is with a few genera only that it is more or less blended with it.

1. This last is the case with some Pteropoda, and Apeneusta, whose intestinal walls, as with the Worms, are partly composed of the hepatic substance, or furnished with numerous small follicles which open into the intestinal cavity.\(^6\)

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\(^{1}\) Helix, Limax, Oncidium, Haliotis, Pterobranchia, and the Pelecypoda. For the internal structure of these glands, see Muller, De Gland, secern, str. p. 84, Tab. XVII.\(^5\)

\(^{2}\) Clio, Aplysia, Thecidia, Lissostoma, Tergipes, and many species of Doris.

\(^{3}\) Janthina, Phlebella, Artscen, and Atlanta. With some Gasteropoda, as for instance, with Rhodope, and Eudinia, there are only two salivary glands; these open in front into the oral cavity and so far from the osphagial that they appear to correspond to the anterior pair of those species in which there are four.\(^\dagger\)

\(^{4}\) Sagitta, Cymbidium, Diedemannus, Denditium, and Chiton.

\(^{5}\) For the internal structure of the liver of the Gasteropoda, see Muller, De Gland, secern. loc. cit. p. 71, Tab. X.; Schlem, De hepate abe Crane et Solius, quaedam, loc. cit. p. 19, Tab. L. II.; Karsen, Nov. Act. Acad. Nat. Germ. XXI. p. 304, Tab. XXI.; and H. Meckel, Muller's Arch. 1846, p. 9, Tab. L.; with Sagitta, the hepatic substance appears to be blended with the intestinal walls (Krohn, loc. cit. p. 8). This is distinctly so with Vesiola, Aequid, Eudinia, Ampharina, and Zephyrina, and is especially seen upon the oral ends of the branches of the intestinal canal which terminate partly in the dorsal appendages, and partly in the pores which are situated in the sides of the body; see Quatrefages, loc. cit. XIX. p. 289, PI. XI. fig. 5, Pl. IV. V.; Alder, Hancock and Embliciton, Ann. of Nat. Hist. XIII. p. 362, PI. II. fig. 9, XV. p. 56, Pl. IV. According to Naudmann (loc. cit. p. 20, Tab. III. fig. 5), the liver is isolated with Tergipes; but as the organ here described appears to open externally by a special duct, it resembles an urinary organ (see below, § 225). With Pneumoderma, and Clio, the stomach is lined with a layer of small hepatic follicles (Curtier, loc. cit. p. 8, fig. 7, p. 13, fig. 11); and Eschricht, loc. cit. p. 31. According to a communication from Kalliker, the intestine of Rhodope also has numerous follicles of this kind, which are pyriform and filled with cells having yellow nuclei.

\(^{\dagger}\) See also Leidy (loc. cit.) for the salivary glands and their intimate structure, of Limax, Helix, Tebennophorus, Fagiulina, Succinea, Glandina.

\(^{\ddagger}\) See also Leidy, loc. cit. for the internal structure, of Limax, Helix, Tebennophorus, Fagiulina, Succinea, Glandina.
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2. With the other Cephalophora, the liver is wholly isolated, nearly always asymmetrical, and often divided into several lobes of a yellowish-brown or brownish-green color; often, also, it wholly envelops the intestinal convolutions. The biliary canals, which arise from the hepatic lobes, form usually, two, three, or more excretory ducts, which empty the bile into the stomach or intestine, rarely into the oesophagus.

Chapter VI.

CIRCULATORY SYSTEM.

§ 216.

For a long time it was erroneously supposed that the circulatory system of the Cephalophora was completely closed. But the heart or central portion of this system, is developed in an inverse ratio to the imperfect peripheral part which is without a capillary net-work. This incompleteness is often so great that, in many genera, the arteries are wanting and the veins more or less wholly absent. The circulation is, therefore, extravascular for a longer or shorter course, and passes into cavities (Lacunae) situated in the parenchyma of the body.

The blood is colorless, often opalescent, and always very poor in corpuscles. These last are also colorless and consist of smooth cells, with a granular, indistinct nucleus.

7 With Dentalium, there are two symmetrical livers, one on each side of the alimentary canal; see Deshayes, loc. cit. Pl. XV. fig. 11; or Sten. Taf. VI. fig. 15, m. m. With Diphylidia, also, there are two livers, one on each side of the stomach into which they open by several transverse excretory canals; see Meckel’s Arch. 1826, p. 15, Taf. I. fig. 11.

8 For the external form of the liver, consult Cuvier, loc. cit. The hepatic ducts open, near the pyloric orifice, with Limax, Helix, Testacella, Davidium, and Dentatum; into the intestine, with Holotis, Vermula, Pleurobranchus, Diphylidia, Doris, Planorhis, and Lymnaeus; into the third stomach, with Aplysia, Dolabella, and Natarchus; while with Quinchiidium, two of the ducts open into the oesophagus, and the third into the first stomach.

9 The tenacity with which the opinion was entertained that there is a completely-closed vascular system with the mollusc, is shown in the fact that Cuvier (Régne anim. I. p. 50), after having seen, with Aplysia, the veins communicate distinctly with the cavity of the body by special orifices, still persisted in the old view, — regarding this as an exception; see Nem. loc. cit. p. 13. It is only latterly that the circulation of the blood through the haemocoe and intercel of the body, has been shown to be the rule, by Pouget (Recherches loc. cit. p. 13), Milne Edwards and Pateneulées (Compt. rend. XX. 1843, p. 201, 730, or Froriep’s neue Not. XXXIV. p. 81, 257).

Milne Edwards, in his memoir already cited upon the circulation of Patella, Helix, Helix, Aplysia, Theis, and Triton, has abundantly shown that the vascular system of the Cephalophora is also incomplete, and that the aorta terminates in a large buccal sinus containing the brain, the salivary glands, the oesophagus with its muscles, and the retracted tongue, and which forms also a part of the visceral cavity; see Ann. d. Sc. Nat. VIII. 1847, p. 37, Pl. I.—III., or Schleiden and Froriep’s Not. V. p. 1, fig. 1—4.

2 For the blood of the Gasteropoda, see Carus,

For the liver of Chiton, see Middendorff (Beiträge zur einen Malacologie rossica, St. Petersburg, 1847, p. 63, Taf. V. fig. 2, 1). Its ducts open into the alimentary canal near the stomach. — Ed.
The heart is wanting in only a few genera of the Cephalopora.\(^1\) Almost always it has a pericardium,\(^2\) and is divided into a simple, very muscular ventricle, and a thin-walled auricle which is equally simple, rarely double.\(^3\)

The arterial blood passes from the respiratory organs into the auricle, thence into the ventricle, from which it is forced through a very short aorta over the body. These two chambers of the heart are usually pyriform, and are joined together at their large extremity by a constriction in which is sometimes situated a valve, which prevents the return of the blood into the auricle.\(^4\)

The position of the heart usually depends upon that of the respiratory organs. It is generally situated at the base of the branchiae, or in the bottom of the pulmonary cavity. It is most often found, therefore, upon the right side of the body.\(^5\)

\(^{1}\) Von den äusseren Lebensleid. d. weiss-and Kalbkleinen Tieres. p. 72; Ehrenberg, Unerkannte Struct. loc. cit. Tab. VI. fig. 1, 11, 1 (Arion and Patella); and Erdl, De Helicia algirae vaisa saugaudiens. Diss. Monach. 1846, p. 10.

\(^{2}\) With Plunorbis, the blood is red. With the Cephalopora in general, there is only a very small quantity of fæces, at least there is only a trace in the blood of Helix; it forms a kind of a web, scarcely visible, uniting the globules into masses and rows. The nuclei of this blood-globules become very distinct by the addition of acetic acid.\(^6\)

\(^{3}\) F. C. H., p. 358, and Darwin (Text. Nat. Hist. XIII. p. 5), have been unable to find a heart with Sagitta; although D'Orbigny (Voy. dans l'Am. mer., or 1836, p. 501) affirms that he has seen the movements of this organ in this enigmatic animal, and Darwin (loc. cit. p. 6) has perceived a pulsating organ at the anterior extremity of the embryo. The heart is wanting, according to Quatrefages (loc. cit. L.), in Sephirina, Acteon, and Amphorina; and according to Kalliker, in Flabellina, Rhodo- hopus, and Limactina. However, Souteyrat (Comp. Rend. XX. 1845, p. 77) contradicts, very positively, the assertions of Quatrefages, and assigns a heart to all the Amnioneta. The difficulties in the study of these animals, from their non-transparency, are undeniably the cause of many of these contradictory statements. One should not, also, conclude as to the organization of the adults from the development of the embryo; for it is very singular that the embryos of Acteon are completely developed without a heart (Furtig, Comp. Rend. XXI. No. 11, XXII. No. 9, or Froment's note Nat. No. 795, and 820), while with the other Gasteropoda the heart appears very early in the embryonic development. According to Nordmann (loc. cit. p. 93), the embryos of Tergipes, which has a heart, are developed as those of Acteon, thus showing that the absence of this organ in these last is only a delay of its appearance.

\(^{4}\) Of Cephalopora (loc. cit. p. 11) has been also equally unable to find a heart with Sagitta.

\(^{5}\) The pericardium is apparently wanting with the Aperature.

\(^{6}\) Chilton, Holocent, Fissurella, and Enagnostophora have two lateral auricles; the last three of these Scutibranchia resemble moreover the Lacedibranchia in their heart being traversed by the rectum; see Cuvier, loc. cit. and Meckel, Syst. d. vergleich. Anat. V. p. 115.
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It lies upon the median line, and its ventricle and aorta are directed forwards, in those genera whose respiratory organs are symmetrical, or wholly wanting. With many other Cephalophora, they have also the same direction, without, however, being situated on the median line; but in the turbinated genera, the apex of the ventricle and the aorta are directed backwards.

§ 218.

The vascular system of the Cephalophora consists almost solely of arteries with their branches, of large venous canals receiving the blood from the cavity of the body, and of the lacunae in the parenchyma which return it to the respiratory organs.

With Sagitta, and some Apneusta there are no traces of blood-vessels; and, as with the Nematodes, the nutritive liquid transudes directly through the intestinal canal into the cavity of the body.

In another series of the Apneusta, there are rudiments of arteries and veins, in the form of a short aorta, which passes in front from the ventricle, and has a bifurcated extremity,—and two vena cava even shorter, which open each side of the posterior end of the auricle.

With the other Cephalophora, the aorta divides, after a short course, into two principal arteries, the anterior of which passes through the esophageal ring, and, sending branches to the cephalic organs, finally ramifies in the fleshy walls of the body; but the other, posterior, ramifications over the organs in the intestinal sac. These ramifications, which sometimes form a beautiful vascular net-work, never pass into a capillary system which

6 The heart is situated on the median line of the back in Dentatium, Tritonia, Scoliaena, Thetis, Phyllidia, Fissurella, and Emarginula; upon the posterior part of the body, with Doris, and Chiton, as is also the case with Onechidium which is remarkable in other respects. It is singular that in Patella, whose respiratory apparatus is symmetrically disposed, the position of the heart is in front and on the right side; see Meckel, Syst. d. vergleich. Anat. v. p. 119, and Arch, für Anat. u. Phys. 1826, p. 19. Several of the Apneusta have the heart on the dorsal median line, as for examples, Tereipes (Nordmann, loc. cit. p. 24, Tab. II. T., Tab. III. fig. 4), Eolidina (Quatrefages, loc. cit. XIX. p. 288, Pl. XI. fig. 5), Aeolus (Hancock and Emberton, loc. cit. PI. V. fig. 13), and Actaeaon (Altmann, loc. cit. p. 149, PI. V. fig. 4).

7 Kron, loc. cit. p. 8. Notwithstanding the absence of a heart and a vascular system with Sagitta, Tritonis, loc. cit. p. 12), has found in the visceral cavity of these animals regular blood-currents, due, probably, to excited organs.

8 Flabellina, Liassoma, and Rhodope, according to Kuliker; Zephyrina, and Amphoria, according to Quatrefages.

9 Such a rudimentary vascular system situated in the anterior part of the back, has been seen by Nordmann (loc. cit. p. 24), with Tereipes, by

Quatrefages (loc. cit. p. 288), with Eolidina, and by Van Beneden (Instit. No. 627), or Frolicq's neue Nat. No. 797, p. 69, with Aeolus.

Altmann, judging from one of his figures (loc. cit. PI. V. fig. 4, c.), has found it also with Actaeaon. Nordmann has observed, that in spite of this imperfection of the blood-vessels, the blood is conveyed into the cavity of the body circulates regularly, so that with Tereipes, the whole body, including the appendages, is traversed by arterial and venous currents which can be traced even to the two venae cavae which arise from open mouths. This circulation is quite like that of insects; except that here, the blood of the Apneusta continues a longer course in the arteries, for Nordmann, with Tereipes, and Quatrefages, with Eolidina, have been able to trace on each side of the body an anterior and posterior branch of the aorta. Quatrefages, however, commits an error at the outset concerning this simple circulation of the Apneusta, in declaring that with these Gasteropods the ramified intestinal canal serves also the function of a vascular system; this has induced him to give the name Phlebenterata to an entire group of these animals. In the controversy between him and Saintvet on this subject (Comp. Rend. XIX. XX.), and which threatens to be interminable, this but has gone too far in asserting that, not only with the Apneusta, but even with all the Gasteropods, there is a completely-closed vascular system. But highly-developed vascular system commencing in a well-formed heart which consists of a ventricle and an auricle, and enclosed in a pericardium. — Lo.
opens into the veins, but gradually disappear, so that it is probable that the blood is effused from their open extremities into the interstices of the parenchyma of the viscera, as well as into the cavity of the body; and is thence taken up through numerous orifices on the inner surface of this last, and conducted to the respiratory organs through the wall-less venous canals, which are hollowed in the muscular substance of the envelope of the body.\(^4\)

**CHAPTER VII.**

**RESPIRATORY SYSTEM.**

§ 219. The respiratory organs are absent with only a few of the Cephalophora; namely: with *Sagitta*, the Apexusta, and with some of the Pteropoda and Heteropoda.\(^1\) With these, therefore, it may be inferred that the respira-

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\(^4\) *Erdt* (De Helice alginæ, &c., loc. cit.) has, indeed, figured venous net-works on the digestive apparatus of an *Helix* (see also his copy in *Carus' Erklarungsstafeln, II. VI, Tab. II. fig. 5*); but I regard these as of an arterial nature, and this so much the more, since *Erdt* in his dissertation, has nowhere shown a direct communication between the arteries and veins. The absence of a capillary network and of venous radicles, is quite apparent with *Arius*, in which the posterior artery forms beautiful ramifications of a white color upon the intestine and liver. If the larger branches of this artery are examined, their muscular walls will be distinctly seen to be internally lined with a granulated layer composed of carbonate of lime which gives the color just mentioned.

If also the smaller branches are examined, their muscular walls will be found to have gradually disappeared so that the blood circulates inside of the granular layer only; and this last in its turn will also be found to have disappeared leaving no trace of capillaries or venous radicles. For the details of the arterial system of the Cephalophora, see the *Memoires de Van Beneden, loc. cit. (Pteropoda)*; *Milne Edwards*, Ann. de Sc. Nat. XVIII. 1854, p. 325, Pl. XI. fig. 1 (Curtioriæ); and *Cuvier, Mêlée, and Delle Chioze*, loc. cit. (Gasteropoda).

\(^5\) Although *Cuvier* in 1828 (Ann. du Mus. d'Hist. Nat. II. p. 209, Pl. II. fig. 1, 2) perceived, on the inner surface of the envelope of the body, the orifices of the venous canals, which as a net-work traverse the flimsy walls of *Aplysia* even to the base of the branches, and although this was confirmed by *Prestinomi* (Biologie, IV. p. 238) and *Delle Chioze* (Memor. &c., 1. p. 65), yet it is only lately that the opinion has been recognized that this might be so with all the Cephalophora, for the observation upon *Aplysia* remained thus long isolated. But now, facts of this kind are so numerous as not to be based upon exceptional observations. It should be understood, however, that the absence of capillaries and of venous radicles, as well as the presence of numerous orifices opening into the venous canals, are the rule with all the Cephalophora which have respiratory organs. These orifices may be easily seen, especially by asphyxiating species of *Limax* and *Arius* — by which experiment, will be appreciated the correctness of *Delle Chioze*’s figure of *Arius* which was engraved in 1839 (Memor. loc. cit. Tab. CIX. fig. 6 without text, and Dessin, loc. cit. II. 1841, p. 10, Tab. XXXVII. fig. 16, the same plate with text), with the exception that there are orifices on their ramifications as well as on the two principal canals. *Poucet* (loc. cit. p. 19, has named these *Orifices absorbants*, and his observations were also made on *Arius*; but *Milne Edwards* and *Valeixen* (Compt. Rend. loc. cit.) have demonstrated this structure with *Aplysia*, *Turbo*, *Pulmonia*, *Scytalina*, *Patella*, *Chiton*, *Haliothis*, *Notarchus*, *Umbrella*, *Pterobranchus*, *Dalmaula*, &c., &c., and therefore with the Nautilibranchia, Gyroibranchia, Southibranchia, Teetibranchia, Pectibranchia, and Pulmonata. I must here repeat that these venous canals are only lacunae excavated in the muscular walls of the body, and are without proper walls, as *Meckel* (System. 4. vergleich. Ann. V. p. 128) has pretended is the case with those of *Aplysia*. To be convinced of their wall-less structure it is only necessary to examine microscopically a longitudinal lined *Arius*. They will be found composed wholly of muscular fibres interlaced in every direction, and some of which surround, sphincter-like, the venous orifices, thus showing that these last are not closed by valves, but by the contraction of these fibres. *Soulelet* himself could not deny this wall-less structure in the veins of the Gasteropoda, although it is not only contrary to his statements against Philbertiana. He declares (Compt. Rend. XX. p. 31, note 3) "que le système veineux des Mullerides n’est pas toujours formé par des vaisseaux dis- twistes, mais qu’il se compose en grande partie de ces caux aux crevassé dans l’épaisseur ou dans l’interstice des organes." See also § 216, note 1.

\(^1\) Respiratory organs appear to be wholly absent in *Sagitta*, and *Phyllophora*. 

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248 THE CEPHALOPHORA. § 219.
tion is cutaneous, which, with the Apneusta, is probably favored by ciliated epithelium.(2) With some of these species, there is an aquiferous system which also serves, perhaps, for respiration.(3)

1. Branchiae.

§ 220.

With nearly all the Cephalophora, excepting the Pulmonata, there is a Branchial apparatus; this is usually very contractile, and always covered with very lively cilia.(4) It is composed either of lamellae, or of filaments arranged in rows or in bundles, or of plumose or pectinate ramified prolongations. With some, the branchiae are situated, uncovered, on the back or on the sides of the body; with others, they are more or less covered by the mantle; but with the majority, they are contained in a special cavity of this last.

This Branchial cavity communicates externally by the Siphon, which is simply a canaliculated, contractile prolongation of the mantle itself.(2)

1. With the Pteropoda, the respiratory organs are very unequally developed. In some genera, they appear wholly wanting, while in others, there is a spacious branchial cavity containing one or two groups of fringed lamellae from which pass out as many veins towards the auricle of the heart.(5)

2. With most of the Heteropoda, there is, upon the median line of the posterior part of the back, a pectinate or plumose branchial apparatus, which connects with the heart by a short vein.(4)

3. This apparatus is most variable as to form and situation with the Gasteropoda, and the different genera of this class are founded upon its modifications. The Cirribranchia have a bundle of small filaments on each side of the neck.(5) The Nudibranchia have on each side of the back, in one or more rows, or in a circle upon the middle of the posterior part

2 The opinion that the dorsal and lateral appendages of Anusia, Isidiana, Venata, Zephyrina, Amphorina, Flabelliga, Callopora, and Ter- giop, are branchi, is untenable, since it has been shown that they contain prolongations of the digestive canal.

3 For the aquatic system of Acteon, and Venula, see below, § 222.


5 For the branchial apparatus of the Cephalophora, I must refer principally to the works of Cuvier (Mémoires, &c.), Saynéz (Descript. de l'Egypte, loc. cit. II. Pl. 1--III.), Meckel (Beiträge zur vergleich. Anat., und Syst. ii. vergleich. Anat. loc. cit.), Quoy and Gaimard (Voyage de l'Astrolabe, or Isla, loc. cit.), and Dele Chière (Mem. et Descr. loc. cit.)

6 With Citio, one does not know what to think of the form and position of their respiratory organs, since that Eschricht (loc. cit. p. 810) has shown that the vascular net-works observed by Cuvier upon the two fins of these animals (Mem. loc. cit. p. 5), and which have been taken for branchial vessels, are only muscular fibres. Van Beneden also, could find no respiratory organs with Lama- cina and Carinera. Moreover, more accurate ob- 
servations are required to determine whether or not the four-rayed cutaneous appendage of the poste-
of the body, numerous fasciculated plumose, or dendritic branchiae. With the Cyclobranchia, and some of the Inferobranchia, the lamelliform branchiae are situated on the furrow which separates the border of the mantle from the foot, under the form of a continuous cord, or of two lateral rows.

With the Scutibranchia, the two pectinal rows, which are wholly concealed in the cavity of the mantle, have, nevertheless, a certain symmetry which is wholly absent with the other Gasteropoda. Thus, all the Tectibranchia have only a single lamellate or pinnate branchia situated on the right side, rarely on the left, and which is more or less covered and sometimes wholly concealed by a fold of the mantle. The Pectinibranchia and Tubulibranchia have a pinnate or pectinate branchia, contained in a cavity which is situated upon the anterior portion of the back and often provided with a siphon on its left side.

With many Nudibranchia, the returning blood from the branchiae is emptied by several veins into the simple auricle of the heart, which (the heart) is situated upon the middle line of the back. With only a few Gasteropoda, as also with the Cirribranchia, Cyclobranchia, and Scutibranchia, the branchial veins are united into two trunks which open into the simple or double auricle. With the other Gasteropoda, which have an uneven, lateral branchia, the blood passes from this last, through a short, simple, venous trunk, to the heart situated near its base.

II. Lungs.

§ 221.

The pulmonary cavity, formed in the mantle of the Pulmonata, is situated

6 With Seguenza, there are, on the back, two pairs of cutaneous lobes, between which are numerous branchial vessels. With Glanceus, there are, upon the sides of the body, three pairs of prolongations which have long, digitiform branchial filaments. With Thetis, the back is surrounded by a double row of semi-pinnate branchiae; while with Tritonia, there is on each of its sides a single row of multiformed branchial tubs. With Doris, and Polycera, there are twenty to twenty-five more or less ramified branchiae, arranged circularly around the arms, and capable, from contraction, of being withdrawn into the mantle.

7 The branchial lamellae form a complete circle with Patella, Chiton, and Phyllidia, and two lateral rows with Diphyllidia.

8 With Fissurella, and Emarginula, there is a row of branchiae on each side of the cavity of the mantle, while, with Halocidus, there are two rows on the left side.

9 With Umbrella, Pleurobranchaea, and Pleurobranchus, this branchia, situated on the right side and half exposed, is easily seen. On the same side also is situated the branchial lamella often deeply concealed between the folds of the mantle, of Gasteropoda, Aplysia, Bullaena, Naticula, etc. But with Doridium, the branchia is on the left side and quite behind.

Ancylos, which differs from the other Inferobranchia by its simple branchia, has, moreover, this peculiarity, that this organ has the form of a simple cutaneous enlargement on the left side, concealed under a fold of the mantle (Treviranus, loc. cit. p. 192, Tab. XVII. fig. 1, 2, 4., or Vogt, loc. cit. p. 25, Tab. II. fig. 1-3, p. 3.)

10 With Voluta, there is a single pinnate branchia which projects out of a cavity in which it is contained (Grintheisen, Nov. Act. Acad. Nat. Cur. X. p. 441, Tab. XXXVIII. fig. 2, 3, 5, 12). The branchia is simple and pectinate with Vernaclus (Philippi, Fammer. Mollusc. Schott. I. p. 169, Tab. IX. fig. 24). Rostellia, and Struthiolaria.

It is bi-pectinate with Turbo, and Janthina, and tri-pectinate with Paludina. With many Pectinibranchia, as, for example, with Harpa, Cassis, Conus, Bucefumum, Tereora, Marx, Voluta, Oliv., etc., there is, besides a very large unpectinate branchia, another organ of this kind which is smaller and bi-pectinate. The epithelium, which covers not only the branchia, but also the walls of the respiratory cavity, plays an important part in the renewal of the water in the branchial cavity, which takes place through its opening, or by the siphon of these Gasteropoda which is situated upon the neck usually a little to the left side.

11 Seguenza, Thetis, Doris.

12 Tritonia, Dentalium, Patella, Chiton, Halocidus, Fissurella and Emarginula. Among the Inferobranchia, Phyllidia should also be cited here. But with Diphyllidia, on the contrary, the veins appear to pass each into the auricle of the heart.

13 The Tubulibranchia and Pectinibranchia.

are unpectinate with Paludina vivipara, and not tri-pectinate, as above mentioned of this genus in general. — Ed.
§ 222. THE CEPHALOPHORA.

at the anterior part of the back, rarely at the posterior part. (1) Its orifice, which can be closed by a kind of sphincter, is upon the right side; it is upon the left with those species only which have sinistral shells, and in one genus alone, it is upon the median line at the posterior extremity of the body. (2) The pulmonary cavity is triangular with those species which have a shell, and round with those which are without it. (3) Its interior is lined with a raised vascular net-work which, with the aquatic species, is covered with a ciliated epithelium. (4) With the naked Gastero poda, this net-work forms a uniformly-meshed trellis; (5) while with the others, there may here be usually seen several large pulmonary veins, which, in passing towards the middle principal vein, are spread over the borders of the respiratory cavity, frequently anastomose with each other, and receive several other veins of a dendritic form. The principal vein opens, at last, into the auricle of the heart at the posterior corner of the pulmonary cavity. (6)

Carefully examined, these veins will be found to be wall-less canals directly surrounded by the transverse and longitudinal fibres of the mantle, so that, apparently, they are only a continuation of the venous canals of the walls of the body.

III. Aquiferous System.

§ 222.

The existence of aquiferous vessels and reservoirs, with the Cephalopora, is not yet satisfactorily settled. However, it appears that here, as with the Acephala, there is an aquiferous system with wall-less canals, of which some are singly ramified, while others form an anastomotic net-work, but all accompany the venous canals and open upon the surface of the body,—presenting an arrangement analogous to the trachean system of insects.

With some Apneusta, the existence of this system, which may have the function of an internal respiratory apparatus, can scarcely be doubted;

1 The respiratory cavity is situated in the middle of the back with Parmaestia, and wholly behind with Testacea, and Onchidiun.
2 Onchidiun. Whether or not the contractile, ramified excrescences at the posterior part of the back of this amphibious mollusc, of which Ehrenberg has counted more than twenty, serve really as branchiae as this naturalist asserts (Synops. phys. anim. evertebrat. Molusca), cannot be determined except from a most exact analysis of these organs. Troschel (Wiegmann's Arch. 1849, 1. p. 107, Tab. VIII.) has shown with more certainty that Ampularia is amphibious, for he found a pulmonary above the branchial cavity communicating with this last, and lined with blood-vessels.
3 With Limax, and Arion, the respiratory cavity has an annular form, its centre being occupied by the heart and kidney.
4 I have found ciliated epithelium in the pul monary cavity of the Lymnaecon, but not in that of Helix or Arion.
5 Onchidiun, Limax, &c.; see Cuvier, Mem. loc. cit. Pl. II. fig. 8-10 (Arion).
6 See Cuvier, ibid. Pl. I. fig. 2-4, and Trevisanus, Beobacht. aus. d. Zoot. u. Physiol. Tab. VIII. fig. 57, 58 (Helix pomatia). In the vascular net-work which Erdt (De Heliciis algirus, &c., fig. 6, copied in Cuvius, Erkliederungstafeln, Tab. II. fig. 10) has figured with many details, all the vascular trunks do not run towards the principal vein, but with some their large extremity is directed towards the border of the lunga.

This disposition, however, does not exist in nature. The pulmonary vessels of this species are arranged like those of Helix pomatia, which is also confirmed by Van Beneden's figure of it; see his Anat. der Helix algiræ, in the Ann. d. Sc. Nat. V. 1856, Pl. X. fig. 3, 6.
for, upon the back and directly behind the heart, there is a reservoir filled with water, from which ramifying canals pass off in all directions. 1 The other observations upon these aquiferous canals of the Pteropoda, Heteropoda, and Gasteropoda, have been but indifferently increased by more recent laborers. With these Cephalophora, the substance of the envelope of the body is permeated by a beautiful net-work of wall-less canals, which are filled with water, it is supposed, through several orifices upon the surface of the body. 2 It is, nevertheless, far from being settled that these canals belong to an aquiferous system, for the existence of their external orifices is doubtful, and it may be urged that they are only a continuation of the venous system. 3 At all events, this question demands further researches based upon facts observed with the Acéphala and Cephalophora.

CHAPTER VIII.

ORGANS OF SECRETION.

I. Urinary Organs.

§ 223.

With most of the Cephalophora, the Urinary apparatus consists of an uneven, lamellate gland, which is usually situated near the branchial or principal...
pal pulmonary vein. Its excretory duct accompanies the rectum and often opens near the anus. 1

The kidney is nearly always of a dirty yellow, or reddish color, of a lamellated structure, and its surface is wholly without vibratile organs. It is surrounded by a sac-like envelope which is continuous with the internally ciliated, excretory duct. Each renal lamella is composed of thickly-set, delicate cells loosely bound together. In their transparent liquid floats an obscure nucleus which, by direct light, appears brown or violet.

These nuclei, which are round and embossed, have a very dense crystalline structure, and are undoubtedly a product of the renal secretion. 2 Certainly they contain the uric acid which is found when the whole gland is chemically analyzed. 3 The ramified canals upon the membranous envelope of the kidneys, return, probably, the blood into the respiratory organs. But in the gland itself no blood-vessel has been observed. 4

With Sagitta, and the other Pteropoda, nothing like a renal organ has yet been found. With the Heteropoda, and Apneusta, on the contrary, there are vestiges of certain organs which further researches may show to be of a urinary nature. 5

With the Pectinibranchia, the kidney is replaced by a gland which is situated behind the branchia, between the heart and liver, and which, in some marine species, secretes the purple liquid.

It is composed of several ramified lamellae, and opens by a large orifice, or by a duct of variable length which accompanies the rectum, at the base of the branchial cavity. 6 With the other branchiated Gasteropoda, the existence of this gland is yet doubtful, although with most of them, and

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1 This is the gland which, with the Gasteropoda, has been considered by the older anatomists such as Sseemanderm, Pฟi, and Blumenbach, as an organ secreting the calcareous salts, and by Cuvier as a mucous gland.

2 This gland corresponds, consequently, as to its position and intimate structure, to the bodies of Boyanuss, which, with the Lamellibranchia, have been considered as kidneys; excepting that they have no ciliated organs. For the intimate structure of the kidneys of Gasteropoda, see H. Meckel, in Miller's Arch. 1840, p. 15, Tab. I.

3 Jacobson (Ieur. de Physiques, XCl. p. 518, or Meckel's Arch. VI. 1829, p. 370) was the first who showed the presence of uric acid in this gland, with Helix pomatia, and memoralis, Liniex niger, Lymannae stagnatiss, and Planorbin cornu. But, some time previous, Dollinger and Wohlfelh (Bld. de Helix pomatia, Wtch. 1815, p. 22) had regarded this organ as a kidney. The presence of uric acid can be easily shown in the dried kidneys of Helix pomatia and Patadina vitaea, for when treated with nitric acid and ammonia, a considerable quantity of mucizeal is discerned.

4 According to Treuwarann (Iezv. nat. d. Anat. u. Physiol. p. 99), with Helix and Arion, a portion of the blood of the lungs, instead of going to the heart, passes into the kidneys, and thence enters the great pulmonary vein. But it must be very difficult to show the course of this liquid in the interior of the kidneys.

5 The spiny surface mentioned by Delhe Chiege (Bescri. II. p. 96, Tar. LXXIII. fig. 3, 4.) as existing near the heart and at the base of the branchiae, with Carcinora, is undoubtedly a urinary gland. The long, yellow ciliated body, but without excretory organs, which Nordmann (loc. cit. p. 24, Tar. II. 4.) observed with Terpsic, between the stomach, liver, heart and rectum, is also, perhaps, a kidney; at all events, as such cannot be regarded another and neighboring body, larger, lobulated and of a yellowish color, having apparently an excretory canal opening externally, and which already has been mentioned as being an hepatic gland. Perhaps a like interpretation should also be put upon the yellow bodies observed by quagifacies in the posterior part of the body of Zephyrina, Acteon, and Amphoreina (Ann. d. Sc. Nat. I. p. 139, Pl. IV. fig. 1-5).

6 With Trilitonum, and Murex, this gland opens by a large orifice into the cavity of the mantle; see Eigenhardt (Meckel's Deutsch. Arch. VIII. p. 216, Tar. III. fig. 4, r.), and Leiblin (Heusner's Zeitsch. fur d. Organ. Phys. I. p. 4, Tar. I. h. b., or Ann. d. Sc. Nat. XIV. 1828, p. 170, Pl. X. b. l). A similar urinary gland has been described with Joninka, by Delhe Chiege (Bescri. II. p. 108, Tar. LXXI. fig. 3, c., LXXI. fig. 14, i, b.), as an accessory respiratory cavity. With Paladina, this gland has a quite long excretory duct; see Cuvier, Mem. Soc. lice. fig. 3, i., p. q. The kidney has, moreover, been described by Cuvier (loc. cit.), and Quay and Gaimard (Voy. de Palestrine Zoö. II. or, Lise, 1834, p. 285, 1836, p. 31) under the names of Maculoporous gland, Organ of the purple, and Departar organ, with Photinaella, Turbo, Buccinum, Mitra, Oliva, Copera, Harpa, Dalium, Cassis, Purpura, Fundus, Auricale, &c. *

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* [§ 223, note 6] For the renal organs with Paladina, see Leydig, Uber Paladina vivipara, Sc., loc. cit. p. 150, Tar. XII. fig. 49, 0. — Ed.
especially with the Nudibranchia, and Tectibranchia, there is a glandular apparatus which may perhaps be of this nature.\(^5\)

With the terrestrial and aquatic Pulmonata, the lamellated kidney is quite distinct. In the species having a shell, it is of riband-like, or triangular form, and situated beside the heart and the large pulmonary vein. Its excretory duct arises from the anterior extremity and passes, first, backwards to the rectum, near the posterior corner of the gland, then turns and runs forwards terminating, finally, in the respiratory cavity near the anus.\(^6\) With the Limacinia, on the contrary, the kidney surrounds the pericardium like an annular collar, and its excretory duct opens near the respiratory orifice.\(^6\)

II. Organs of peculiar Secretions.

§ 224.

Mention has already been made of the parts of the mantle which secrete the calcareous substance,\(^1\) and further on, I shall speak of the different glandular appendages attached to the genital organs.\(^2\)

As to the other organs of particular secretions which are less common, I will mention the following:

1. With those Apneusta which have cutaneous appendages, there is, in the dorsal and lateral lobes, a follicle whose excretory orifice opens at the extremity of the lobe, and which secretes a granular mucous substance, and peculiar corpuscles which resemble the netting organs of certain Zoophytes.\(^3\)

\(^7\) With Doris, there is found between the lobes of the liver a gland, which sends off backwards a long excretory duct which opens externally close by the anus and has sometimes near its extremity, a vesicular dilatation. This gland, formerly taken for a liver, is probably a primary organ; see Cuvier, loc. cit. p. 16, Pl. I. II. ; Medcl, Beitir zur vergleich. Anat. I. Hist. p. 9, Taf. VI. fig. 3, I. and Delle Chiaje, Descr. II. p. 25, Tav. XIII. fig. 12, a. y. C. fig. 21.

The orifice found with Thetis, directly behind the anus in the dorsal region, is also in communication with a gland may be regarded as a kidney; see Cuvier, loc. cit. fig. 1, e. and Delle Chiaje, Descr. II. p. 53, Tav. XLVII. fig. 1, s., XLIX. fig. 3. Delle Chiaje (Ibid. Tav. XLIII. fig. 1, s.) has seen with Tritonia, a similar gland opening into the rectum; and with Gasteropterom (Ibid. p. 59, Tav. XV. a. n.), another situated between the base of the branchia and the heart.

The large triangular glandular mass, which, with Aplysia, is situated in the cutaneous fold enveloping the shell, and lies in the space between the heart, the base of the branchia and the anus, secretes a large quantity of a red liquid; this also is probably a kidney; see Cuvier, loc. cit. p. 11, Pl. II. fig. 1, C. D. E. fig. 3, B. C. D., and Delle Chiaje, Mem. II. p. 55, Tav. II. fig. 2, t. r. 5, 6.

With Vermeculums, and Mogilus, there is an analogous gland behind the branchiae. However, this renal apparatus of the branchioporous Gasteropoda demands a more careful investigation in both an histological and a chemical point of view.\(^8\)

8 See the figures of the kidney of Heinis and Lymnaeus in Cuvier, loc. cit., and in Trevisanus, Beobacht. Kr. Tab. VIII. fig. 58; see also Parus, in Wiegmann's Arch. 1843, I. p. 78, and, De Gasteropodum nonnullorum hermaphroditism, system. genet. etezopeses. Diss. Berol. 1842.

9 See Cuvier, loc. cit. II. fig. 8-10, and Trevisanus, Beobacht. Tab. IX. fig. 59 (Arian), and Parus, loc. cit. p. 82.

10 See § 263.

11 See below, Chapter IX.

12 Those glandular follices which, from spontaneous contraction can empty their contents, communicate, according to Quatrefages (Ann. d. écl. Nat. XIX. p. 257, 259, Pl. XI. fig. 5, 6), with Endina, whose structure consists of arboroseent digitation from a central canal. — En...

\[^{10}\] [§ 223, note 7.] See, in reference to this gland with Doris, Aider and Hanawock, loc. cit. Part V. Pl. II. fig. 1, g. g.

For the renal organs of Chiton, see Middenhoff, loc. cit. p. 72, Taf. VI. fig. 1, N. and Taf. VII. fig. 3, N. They consist of a velvet-looking substance which stretches on each side of the body, and the tendinous mass of the ventral muscles, and join together horseshoe-like on the anterior border of the posterior diaphragm. Their intimate
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2. The genus Aplysia has an apparatus of particular secretion, consisting of a group of pyriform follicles situated under the branchia, inside of the skin. Its excretory orifice is behind the female genital opening, and its secretion is a whitish liquid with attributable corrosive qualities. [6]

3. Many of the Pectiniibranchia, and Tubulibranchia, have upon the upper wall of the cavity of the mantle, a row of folds which secrete an extraordinary quantity of viscous mucus which is not excreted through any particular duct. [6]

4. With several terrestrial Gasteropoda, the median line of the foot is occupied by a straight canal lined with ciliated epithelium, which ends in a large orifice situated under the mouth. On each side of this canal, are rows of follicles that secrete a granular mucus which, passing into its cavity, is excreted externally, probably by mean of cilia. [6]

CHAPTER IX.

ORGANS OF GENERATION.

§ 225.

The Cephalophora propagate solely by means of male and female genital

by a narrow canal, with the prolongations of the digestive cavity which enter into the dorsal appendages, and their contained liquid is subjected to a process of respiration. But Nordmann (loc. cit. p. 33, Tab. II. R. R.) has been unable to find any such communication between these two organs, with Tergipes, and he has distinctly seen the granular mucus which is expelled from the follicles from contraction, escape through an orifice on the extremity of each dorsal appendage. With Actelis, according to Hancock and Embleton (loc. cit. p. 80, Pl. IV. V.), the product of these follicles is quite interesting. It contains elliptical vesicles which immediately burst when put in water, exposing a transparent cylinder, out of which a filament, sometimes of a spiral form, is projected as swift as lightning. They compared these bodies to spermatozoa; but to me, they appear exactly like the settling organs of Actelis. Hancock and Embleton have also seen and figured with Actelis, a canal of communication between these follicles and the prolongations of the digestive canal, but it may be questioned if this was not an artificial formation produced by compression of these organs during the examination. 

4 See Cuvier, loc. cit. p. 4, fig. 2, π; Delle Chiinge, Memor. II. p. 56, Tab. II. fig. 2, 0; fig. 3; and Rang, Hist. Nat. des Alcyonides, p. 28.

5 These muciparous organs described by Cuvier, with Buceinum (Mém. loc. cit. p. 6, fig. 3, f) are the

* [§ 224, note 2.] See for further description, together with figures of these peculiar bodies containing a spiral thread, Alder and Hancock, loc. cit. Part III. Pl. VIII. fig. 14 (Actelis); they correct their former view (mentioned above) and admit, what I think is not in the least doubtful, that they

Feuilletes maugeuses, are also found with Murex (Eyringhale, in Meckel's Deutsch. Arch. VIII. p. 213, Taf. III. m. m.), Terebra, Turbo, Falata, Cypraea, Harpa, Dolium, Cassis, Tritonum, &c. (Quoy and Gaimard, Voy. de l' Astrolabe, loc. cit., or Isis. 1836, p. 55, Taf. XI. fig. 6, o, Taf. XIII. fig. 10, X. 18, m). Carus (Museum, Stockenau, Heidelberg. II. 157, Taf. XII. fig. 8, h.) has seen similar mucous folds with Magilus. With Veneridae, on the contrary, I have found only a single, but a very considerable, longitudinal fold which runs along the side of the rectum and covers the excretory duct of the genital organs.

* This muciparous apparatus of Bulimus, Helix, Litorina, and Arion, was announced in 1829, by Kleeborg, at the Congress of Naturalists at Heidelberg (Isis, 1830, p. 571); but it had not escaped the observation of Delle Chinge with many Helicina and Littorina (Descriz. II. p. 18, Taf. XXXVII. fig. 17, x). It is therefore surprising that it remained thus long unknown to other naturalists. The assertion of Kleeborg, that with Littorina and Arion, the mucous canal communicates with the venous system, I have been unable to confirm by observations upon Arion. Leydig declares that this mucous canal with the terrestrial Gasteropoda is the seat of the sense of smell; see Schleiden and Frerrey's Notiz. IV. p. 24, or Ann. of Nat. Hist. XX. p. 210.
organs. These are either combined in one individual, or the sexes are separate.
In most species there are copulatory organs. The genital organs have several uneven divisions, which, when fully developed, are arranged as follows: A **Tuba Fallopii** passes from the ovary into the uterine sac, at whose base is an organ which secretes albumen, while at the point where it is continuous with the vagina, there is a **Receptaculum seminis**. The male genital organs consist of a testicle, a **Vas deferens**, and a **Ductus ejaculatorius** which opens into a retractor penis.
With the hermaphroditic species, these two kinds of genital organs are more or less blended together, — the testicle with the ovary, and the **Vas deferens** with the **Tuba Fallopii**; very often also the vagina is united with the **Ductus ejaculatorius**, forming a cloaca into which open several particular secreting organs. These different male and female organs are usually lined internally with ciliated epithelium.

The eggs of these animals have, at their escape from the ovary, a round and sometimes an ellipsoidal form, and are composed of a thin chorion enclosing a finely-granular vitellus of variable color, which contains a germinal vesicle and dot.\(^1\) The sperm is white and opalescent, and quite crowded with very active spermatic particles. These last are either of the form of **Cercaria**, or consist of a very long filiform body, one extremity of which is inermassated and often of a spiral form. The trembling, undulatory movements of these particles cease when placed in water, with those species which have copulatory organs; they become twisted into loop-like forms and are finally rigid and motionless.\(^2\)

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1 See Carus, Erbluterungsstfinden II, Taf. II, fig. 4, 5 (Limax), and in Müller's Arch. 1835, p. 491, Taf. XII, fig. 2 (Helix pomatia); Wagner, in Weigmann's Arch. 1833, I. p. 266, and Pros- 

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dromus, loc. cit. p. 7, Tab. I, fig. 6, 7 (Heitz and Baccinum); and Allman, loc. cit. p. 192, Pl. VII.

2 Wagner and Erdl (from Friege's neue Notiz, No. 249, p. 95) have found with Chiton, Patella, and Haliotis, spermatic particles of a Cercarian-form, tho' p1 with a long body to which is abruptly at- 

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tached a hair-like tail. I have seen a similar form with Verrucous gigas and triguetor. These of Trachus also have this form, according to Kuhl- 

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ker (Beitr. loc. cit. p. 25), but the middle of their body has a slight constriction. They are hair-like, and taper at both extremities with Turbo, Bacciu- 

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num, Patula (Kölliker, loc. cit. p. 23, Taf. I, fig. 5), and Sagitta (Krohn, loc. cit. p. 10, fig. 12).

With other marine Gasteropoda, as for example, 

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Carnaria, these particles are hair-like, but with one of their extremities slightly incrassated (Müle Edwards, Ann. d. Sc. Nat. XVIII. p. 324, Pl. XI. fig. 7); and with Doris, Terebrapis, and Patulina, this thickened extremity has a spiral form (Köll- 

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ker, Beitr. loc. cit. p. 55, Taf. I, fig. 6; Nord- 

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mann, loc. cit. p. 52, Taf. III, fig. 8, 9, and my observations in Müller's Arch. 1836, p. 240, Taf. X.). With the pulmonate Gastropoda, the spermatic particles have only a short incrassated extrem- 

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ty of a spiral form; see my observations loc. cit. 1836, p. 45, Taf. II; Passow, in Weigmann's Arch. 1843, T. p. 71, Taf. V., and Jaffard, Ob- 

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serv. in Microscope Atlas, Pl. III.

The development of these spermatic particles takes place in two large cells (Mother-cells), in which are formed others (Daughter-cells) which are changed into the spermatic particles. But the cell- membrane of the mother-cell, disappears quite early and its contents are condensed into a solid nu- 

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cleus around which are grouped the daughter-cells, ultimately forming a bundle of spermatozoa. See, 

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beside these observations of Kölliker, Nordmann, and Passow, loc. cit., those of H. Meckel, in Mul- 

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ter's Arch. 1844, p. 453, Taf. XIV. fig. 9-35, and the more recent researches of Kölliker, in the Neue Denkschrift, d. allgem. schweizer. Gesellsch. f. d. 

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gesamt. Naturwissensch. VIII. 1846, p. 4, Taf. I. fig. 1-30 (Helix pomatia). The presence of two kinds of spermatic parti- 

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cles in the sperm of Patulina viripara, is a very remarkable fact; see my observations in Müller's Arch. 1836, p. 245, Taf. V., X.

Beside the hair-like spermatic particles already mentioned, there are long cylindrical bodies, from one of the extremities of which project many delicat- 

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filaments having very lively motions. These have been described by Ekrenberg (Symbol. physic. Anim. overeadet. Dec. I. Pigymus cin- 

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non, Appendix) as parasites under the name Pha- 

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cetura patulinae. Passow (Weigmann's Arch. 1843, p. 99, Taf. V. fig. 8), on the other hand, regards them as bun- 

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dles of spermatic particles of the normal form, and Kölliker (Beitr. loc. cit. p. 55, and Neue Denkschr. 

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loc. cit. p. 41) considers them only as two forms of the same kind of spermatic particle; the second he regards as elongated mother-cells containing many ordinary spermatic particles.

For my part, I do not know how to explain this fact, and I would willingly place the second form in the category of Spermatozoa; but against this opinion, as against that of Kölliker, and Passow, it can be urged that, with the second form, the ex- 

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 tremities are never thickened or spiral, as is true of the first, and that both forms are simultaneously developed in the testicle.\(^4\)
§ 226.

Among all the hermaphrodite Cephalophora, the genus Sagitta stands wholly alone, in having all parts of its genital apparatus double.

The ovaries consist of two straight, non-ciliated tubes situated at the posterior extremity of the cavity of the body; these open externally by an arcuate orifice, situated upon the back directly over the median line of each of the posterior lateral fins.

The two internally ciliated testicles fill the caudal cavity, which is divided into two chambers by a longitudinal septum. They send backwards two short deferent canals, which open in front of the caudal fin, but to some turbidity, but are without copulatory organs.\(^1\)

§ 227.

As for the other hermaphrodite Cephalophora, to which belong the Pteropoda and a majority of the Gastropoda, the genital organs of the Nudibranchia, Inferobranchia, Tectibranchia, and Pulmonata, have been the most thoroughly investigated. But the different divisions of these organs have been interpreted in a manner so varied and contradictory, that one can almost despair of having any positive knowledge of their relations.\(^1\)

1 See Krohn, loc. cit. p. 9, fig. 2, 7-9. The ciliated epithelium which covers the male genital organs of Sagitta, from the posterior extremity to the genital orifice, produces a general upward and inward movement of the sperm in the testes, a phenomenon which Darwin has compared to the motions of the sap in Chara (Ann. of Nat. Hist. XHI. p. 3, Pl. 1, fig. 1, or Frutiger's neue Notiz. No. 633, p. 3, fig. 62, and Ann. d. Sc. Nat. I. 1844, p. 372, Pl. XV. B). For the genital organs of Sagitta, see also the researches of Wilms (loc. cit. p. 12).

1 It has been quite difficult to receive the fact that, with these animals, the testicle and the ovary are united in a single body,—the Hermaphrodite gland. Cuvier, whose opinion has been followed by Meckel and Carus, in their different publicaitions, regarded this gland, with the Pulmonata, as an ovary, and the albumen-secreting organ, as a testicle. Trevisanus (Zeitschr. für Physiol. I. p. 3. V. p. 140) was of the opposite opinion; he considered the hermaphrodite gland as a testicle and the other as an ovary. This view has been adopted by Precoast (Mem. d. L. Soc. Phys. de Genève, V. p. 113, and Ann. d. Sc. Nat. XXX. p. 85, 41), and by Preusch (Bull. loc. cit. and Wiczmann's Arch. 1845, L p. 71, 1845, L p. 34).

In England, Rymer Jones adopts the view of Cuvier, and Owen that of Trevisanus. Willard (loc. cit. p. 32) names as ovary, the albumen gland; and as testicle, the half-canal which runs along the uterus; but he is in doubt as to the function of the hermaphrodite gland. Erard, who recently gone over the ground, according his views with those of Siebold and others above-mentioned (see Botrley, loc. cit. in Siebold and Kolliker's Zeitscb. II. 1850, p. 135, Taf. XIII. fig. 21-43). Legdig, however, has watched their formation from cells; and here I may remark as being evidence against their being spermatic particles, that, according to him, they are produced by the metamorphosis of an entire nucleated cell, and not, as is the grand law with spermatic particles, from a cell-nucleus. From this and from the above-mentioned reasons, based upon analogy, I cannot admit that these peculiar bodies are true spermatic particles. Legdig's observations on their development of course render invalid the hypothesis of Gratialet that they are modified spermatic particles, having undergone changes, like those of the Helix, in the Fucicella copulatrix; see Jour. de Conchol. No. II. 1859, p. 116, and No. III. p. 226, Pl. IX. fig. 3-7. — Ed.
attributes to this last the function of an ovary (Behr. zur Anat. d. Heidenh., loc. cit.), has expressed no positive opinion as to the function of the albumen gland. Steenstrup (Ueberschæfer.over Hermaphroditismus Thiereae; 1 Naturen, 1845, p. 76, Tab. 11.) has expressed a very singular opinion on the subject of the genital organs of the Pulmonata. He regards the gastropods as of separate sexes with which the different parts of the genital apparatus are double, and that only one side is developed, the other remaining atrophied as in female birds. According to this, the hermaphro- dite gland would represent the active ovary, in the individuals which Steenstrup regards as females, and the albumen-gland would be the ovary on the other side imperfectly developed. The uterine canal would belong to the active side, the Vas deferens would be the abortive uterus on the other side, and the penis as an abortive analogous vesicle would correspond to the pedunculated vesicle of the active side.

In the other individuals of the same species regarded by Steenstrup as males, the hermaphro- dite gland would be the active testicles, and the al- bumen-gland, the same organ on the other side, abortive; the uterus would be the developed Vas deferens, and the proper Vas deferens the unde- veloped organ on the other side. The pedunculated vesicle would have the same significance as with the female individuals, and the penis would be this vesicle imperfectly developed.3

2 After R. Wagner (Wiegmann's Arch. 1836, l. p. 570) had found in various Pulmonata, eggs and spermatic particles at the same time in one and the same genital gland, and I myself had expressed my conviction (Ibid. 1857, l. p. 61) that with these Gastropoda the ovary and testicle were united in a single organ, H. Møcket was the first who de-

scribed exactly the structure of this hermaphrodite gland (Møcket's Arch. 1844, p. 483, Taf. XIV. XV).

It is, therefore, astonishing that Steenstrup (Ueberschæfer. of hermaphroditismus Thiereae; 1 Natur. 1845, p. 76, Tab. 11.) figures, him, and he, judging from his figures, saw distinctly the line of separation between the ovarian and testicular follicles. It has determined two fragments of this gland taken from different individuals of Helix pomatia, as being one an ovary, and the other a testicle. In this last-mentioned fragment, he has called spermatic cells not only those really such of the internal follicle, but also the eggs contained in the external follicle; while in the first-mentioned fragment, or the so-called ovary, he has named as eggs not only the real eggs but also the internal spermatic cells.

The spermatic particles, which he also saw at the same time, would, according to him, be brought out by coition.

3 Under the Pulmonata, Kolliker (Zoologische. 1837, p. 39) has found the hermaphroditic gland with Hyoela. From this, the eggs, described by Ciaver, C. Smidt, and I. Mendel, may be regarded as an hermaphrodite gland, and as invaginated excretory follicles. Under the Agamids, this gland has been seen by Kolliker, with Aegina, Lissosoma, and Flabellina. It exists also with Acteon, judging from the description of Albana (loc. cit. p. 102. Pl. VI. VII. fig. 8) of its voluminous and multiform ovaries, in which, he says there are observed beside the projecting sacs filled with eggs, others smaller filled with a granular substance. The first are very probably ovarian, and the other testicular follicles.

Terebræ, also, has a similar ramiﬁed ovary; but it was incorrectly interpreted by Nordmann (loc. where the androgenous apparatus is minutely de-

scribed. These authors assert that although self-insemination is perhaps, possible, yet there is usually a congress of two individuals, and therefore a reciprocal copulation.

See also upon this point,—the real relations of the hermaphroditic gland, Gratelet, Jour. de Conchol. 1850, No. 11. p. 116.—Eo.}

The testicular follicle and the deferent canal are lined with ciliated epithelium, which, however, is wanting in the ovarian follicle.

The disposition of the various parts of the genital apparatus varies very much according to the families and genera of these hermaphrodite Cephalophora. The two invaginated excretory ducts of the hermaphrodite gland either pass to the base of the uterine, or the Vas deferens leaves the Tube Fallopii a little way from it, and passes in a tortuous course to the penis. In the first case, the Vas deferens leaves the Fallopian tube at the point where it enters the uterus, and continues its course on the sides of this organ, but as a semi-canal open upon its inner surface.

In some genera, this semi-canal continues on along the vagina to the genital cloaca, while in others, it becomes a complete canal upon leaving the uterus, and passes, after a longer or shorter course, into the penis.

The Vas deferens has, at different points of its course, glandular or vesicular appendages, which sometimes contain sperm. These may be compared, on the one hand, to an Epididymis or Vesicula seminalis, and, on the other, to a Glandula prostate.

At the base of the uterus there is an Albinum-gland which is usually tongue-shaped, and sometimes very long, being rolled up and bound together by a cellular tissue so as to have a round form. The walls of this gland are composed wholly of cells filled with drops of albumen which is undoubtedly used to envelop the eggs as they pass into the uteri.
The Uterus is very often a long, large channel, with transversely plicated glandular walls; it is distinctly separated from the ensuing vagina, though, but often, it is only a simple dilatation of the oviduct, which is sometimes insensibly continuous with the vagina. This last communicates usually with the excretory duct of a pyriform vesicle, which, as a Receptaculum seminis, is filled with fresh sperm directly after the epoch of procreation. This vesicle has, moreover, sometimes a lateral, caecal diverticulum.

13 This Receptaculum seminis was formerly designated under the name of pedunculated vesicle; although Trevisanus regarded it as an urinary bladder, and, with Arion, erroneously ascribed to it a communication with the kidney (Zeitsch. f. Phys. p. 10). However, there can now be no further doubt as to its nature, for if its contents are examined shortly after abortion, they will easily be found to consist of fresh sperm containing fully-developed, active, spermatic particles. Later the spermatic, which matures in a redish or a yellowish color, sometimes traces of dead, rigid spermatic particles. The resemblance of this matter then to excrement is, without doubt, the reason why this organ has been compared to a urinary bladder, or confounded with the sac for urine (kidney) of other Cephalophora.

With the Periperae, this organ is a pyriform vesicle with a short peduncle,—at least with Clio (Eschricht, loc. cit. Tab. III. fig. 25, s.), Cymbula, and Limacina (Van Beneden, Exerc. zoo. loc. cit. PL I. fig. 17, d. V. fig. 12, A, where this organ is figured as a sac for purple). The absence, also, has a sac for feculation; and if I can give no other name to a long-pedunculated, pyriform vesicle which Nordmann (loc. cit. p. 49), Tab. II. fig. 11, III. fig. 5, b. 4), has described as a testicle with Terzipes; and so much the more as he always found perfect spermatic particles, and not developing seminal cells.

The pedunculated vesicle with its semi-liquid contents, which Altman (loc. cit. p. 152, PI. VI. 3.) has observed with Acteaon, is also a Receptaculum seminis. According to Kolliker, this organ also exists with Flabellina and Rhodope, as a pedunculated vesicle communicating with the intestine of the vagina. The excretory duct of this organ is short with Thetis (Carver, loc. cit. fig. 7, c.); Dela Chioeje, Desorci, loc. cit. Tab. XVII. fig. 1, d.), with Acteaon (loc. cit. PL IV. 5, b.), and with Chiocjeje, Memori. loc. cit. Tab. IV. fig. 1, p.), and Pleurobranchus (H. Meckel, loc. cit. Tab. XV. fig. 5, n. fig. 1, q. 7. 6.). It is longer with Segalin, Batta, Baluca (Cuvier, loc. cit. fig. 5, l. 10, i.), Doridium, Tritonia, Umbrella, Diaphilia (H. Meckel, loc. cit. Tab. XV.), and Natura (Della Chiocjeje, Desorci. loc. cit. Tab. LXIX. fig. 5, n.). In the Pulmonata, this peduncle is very long with Helix, and Clausilia; is so, with Lymnaea, Planorbus, Bulimna, and Physa, and pretty short with Limax, Arion, and Sucinaeae (see the figures of Carver, Wieder, Trevisan, Ered, and Pauch, loc. cit.)

14 This diverticulum exists with many Helicinna.

De St. Simon (Observations sur l'organe de la Glaise des Gasteropodes terrestres et fluviales, in the Jour. de Conch. 1853, p. 1) this author is very minute in his details on the color, form, and size of this organ, with these animals. — Eo.

* [§ 227, note 9.] For the mucous apparatus with the Pulmonata, see Ailer and Hannecke, loc. cit. Part II. PL IV. fig. 15, (Dota); Part III. PL VIII. fig. 2, g. e. (Ena); Part IV. PL V. fig. 8, l. (Eumenis); Part V. PL II. fig. 7, b. h. (Doris); also Hannecke, Ann. Nat. Hist. VIII. 1853, p. 149, PL III. fig. 6, g. (Antipoda). See also

15 This Receptaculum seminis is very long with Heliothis and Clausilia; is so, with Lymnaea, Planorbus, Bulimna, and Physa, and pretty short with Limax, Arion, and Sucinaeae (see the figures of Carver, Wieder, Trevisan, Ered, and Pauch, loc. cit.)

§ 227. This receptacle is the organ called genital bladder by Leidy, and which he

as a mucous or an urinæ gland. It is tongue-shaped with nearly all the Pulmonata (see the figures of Carver, Trevisan, Ered, Pauch, &c. loc. cit.). It is a round, glandular body with Thetis, Tritonia, Umbrella, and Cephalophora (H. Meckel, loc. cit. Tab. XV. fig. 1, 12, 15, 17). According to Kölleter, there is with Rhodope, and Limacina, a similar gland annexed to the uterus; and without hesitation I should pronounce as of the same nature, the glandular body which Altmann (loc. cit. PL VI. 7.) has described as a testicle with Acteaon. With Doris, Aplysia, and Diaphilia, it is a twisted knotted tube (H. Meckel, loc. cit. fig. 2, 7, 10).

10 Such is the case with the Pulmonata (see the figures of Carver, Trevisan, Ered, Pauch, &c. loc. cit.). Undoubtedly the glandular walls of this utricle secrete the calcareous crystals which increase the eggs of many Helicinna (see Tarpin, Analyse microsc. de l'œuf du lamacoen, in the Ann. d. Sc. Nat. XXXV. 1832, p. 436, PL XV.), or which supply the glistening substance enveloping in the form of a cylinder or a disk the eggs of the Lymnaecæa (Pfeiffer, Natür. deutsch. Land- und Wasserzoo. Holmioen. Abth. I. Tab. VII. VIII.).

11 With the Periperae, the common excretory duct of the pharyngopterous gland, before passing into the vagina, has one or two dilatations, the inferior of which corresponds perhaps to an uterus (Fan Beneden, Exerc. zoo. loc. cit. PL III. fig. 18, e. IV. fig. 6, d, and II. fig. 4, d. Hapten, Cleodora, and Cuviera). With Clio, Cymbula, and Limacina, it is not yet determined whether the dilatation which is here found belongs to the definitive canals of the ovary, and therefore the name of utricle cannot be given to it.

12 The utricle is short and is directly continuous with the vagina with the Nutilbranchus, infrabranchus, and Pulmonata (H. Meckel, loc. cit. Tab. XV.), and perhaps also with the Aspastra. I am sure you will not object to this unanalysed utricle as formed the envelops which, in the form of a riband, a cord, or a capsule, surrounds the eggs of the Nutilbranchus, the Pulmonata, and the Aspastra. Thus with Aplysia, Doris, Tritonia, Acteaon, &c., their sperm is named a riband or cord; and with Glauca, and Acteaon, it is wound in a spiral manner about various objects; while with Terzipes, it is tacked on to marine plants under the form of little-shaped capsules with short peduncles. With Tritonia, Acteaon, and Aplysia, there is observed the remarkable fact that there are several vessels each surmounted by an analuminous layer, in one and the same envelop; see Sars, in Wetzmann's Arch. 1857, p. 402, 1810, L. p. 196, Tab. V.--VII.; Fan Beneden, Ann. d. Sc. Nat. 1841, p. 123, PL 1; and Lovén, in Lais, 1842, p. 359.
Underneath the point of insertion of this vesicle upon the vagina, are various glandular appendages which open into this last or into the genital cloaca. But as yet their function is unknown. With the Pteropoda, and Heterobranchiata, there is a single appendage only, consisting of a simple tube. To this same category belongs, also, the dart-sac,—a very remarkable cylindrical organ opening into the genital cloaca. Its walls are quite thick, and on each side of its base is a group of more or less numerous caeca. At the bottom of this sac is a conical papilla which secretes a calcareous concretion of the form of a lance-head with the point downwards,—the Dart. This is projected during copulation, and often remains sticking in the skin near the genital opening. Its loss is subsequently replaced by the secretion of another in the same place.

The male copulatory organs consist of a more or less long, projecting Penis, which, when at rest, is either retracted freely between the other viscera of the cavity of the body, or enveloped wholly or in part in a proper sheath (Penis). This penis consists, nearly always, of a hollow fleshy cylinder, which is usually closed at its posterior extremity, and has, behind, a long flagellum.

It is very long with Bulimus rufus, Helix arboricola, and vermicularia; very short, on the other hand, with Helix pomatia, nemoralis, and candadissima. It is entirely wanting with Helix guttata, striatula, and rhodostoma. With Helix algera, it communicates directly with the seminal sac (see the figures of Erdt, and Pausch). With Doris, the Receptaculum seminis has a peculiar structure; it is kidney-shaped, and from its concavity arises a very large excretory duct, uricarium, and openings into the genital cloaca, which has not only a caecal appendage, but also a short canal that communicates with the base of the uterus (H. Meckel, loc. cit. p. 446, Taf. XI. fig. 3). Further research must determine if the canal which Yordmann (loc. cit. p. 36, Tab. III. fig. 5, d.) has observed upon the seminal sac of Tereregis without being able to trace it to its extremity, is a simple derviceritum, or a canal communicating with the female genital organs.

An anal-oral appendage, of a round form, has been described with Cymbulia, and Laimina, as a parasite by Van Beneden (Ecrua. loc. cit. Taf. IV. fig. 17, c. V. fig. 12, b.), and its cavity by Eshricht, with Olia (loc. cit. Tab. III. fig. 25, 29). There is a long glandular appendix upon the genital cloaca with Doratifoma, Pterobranchiata, and Diphytilia (H. Meckel, loc. cit. Taf. XV.). As yet the function of this gland is only hypothetical. Perhaps it furnishes the viscid substance enveloping the eggs during their deposition, or it may be a copulatory pouch (furina copulatrix). But it is quite probable that the penis enters the phalange of the Receptaculum seminis during copulation, for with most Cephalopora the penis and the phalange are of the same length.

The dart-sac, which is more or less long, is found with many species of Helix. It is absent with Helix algera, candidissima, velaria, and verticillata. It is double with Helix eradicata, and with Helix striatula, is replaced by two very long caeca; see Wohlschlag, Erdt, and Pausch, loc. cit.

II. Two considerable groups of dichotomously ramified caeca are found with Helix pomatia, aterpura, anastrica, lactea, lactichedia, and vermicularia, while with Helix umbrosa, striatula, and striata, there are only four caeca on each side. With Helix inornata, and nemoralis, there are three, and two only with Helix tardiana, arboricola, and peninsula; see Carus, Wohlschlag, Erdt, Pausch, loc. cit. and Waser, loc. cit. Tab. XXX. fig. 11, 12. As to the use of these glandular tubes, I would suggest the view that they secrete a viscid substance, which, during the coition, envelopes the sperm like a spermacophorous to conduct it into the seminal sac. Indeed, I am now inclined to regard as the residue of a spermacophorous the thin hag body of a peculiar aspect, which, with Helix horridus, arboricola, and nemoralis, often project out of the genital cloaca after copulation, and which, when they have left it, are rolled in a spiral form at both extremities. When carefully examined they will be found composed of a second layer of conculated albumen, and to be lavished in the pelvis of the Recipientum seminis; see Haeckel, in Meckel's Arch. 1833, p. 82, Tab. VII. fig. 3, and Carus, in Muller's Arch. 1835, p. 435, Tab. XII. fig. 4-7.

The dart is hollow and of the form of a cylindrical style with Helix eradicata, and striatula; but with Helix pomatia, tartara, and aterpura, four sharp denticulated edges, extending its whole length give it a very elegant form; see Prevost, in Mem. de Genève, loc. cit. V. p. 121, VI. fig. 7, and Carus, in Muller's Arch. 1835, p. 434, Tab. XII. fig. 9, 12.

It is probably an excretory organ, for the snails reciprocally prick each other before copulation.

* § 227. THE CEPHALOPORA. 261

has so well figured. It has found its contents to be spermatogenic particles, but, in regard to its being a seminal receptacle, he remarks: "This, however, cannot be considered wholly as its use; for it secretes a mucoid matter which may probably facilitate the passage of the ova through the vagina and cloaca," p. 234.—En.  

* § 227, note 18.] For the relations of the dart-sac with the American Helices, see Leidy, loc. cit. He adds, "The dart-sac and multilobed vesicles, so common in European species, are very rare in American species." The dart-sac has been found in only four species. —En.
form prolongation (Flagellum). In many of the genera of the Gasteropoda, the Vas deferens is inserted upon the penis near its base, or at the posterior end of its cavity.\(^{22}\) The penis has also inserted into it many small retractor muscles which arise from the walls of the envelope of the body, or on the columnella.\(^{22}\)

The external orifices of these hermaphroditic genital organs are usually on the right side, and present the following relations: 1. The vagina and penis open into a common genital cloaca which communicates externally upon the sides of the anterior part of the body.\(^{23}\) 2. The two orifices are situated side by side,—that of the penis directly in front of that of the vagina.\(^{23}\) 3. The orifices are quite removed from each other, and then the penis, which is usually concealed beneath the testicle of the right side, communicates with the genital cloaca situated behind, by a groove which runs along the sides of the body.\(^{22}\) This groove is lined with ciliated epithelium, and, without doubt, conducts the semen from the genital cloaca to the penis, during copulation.

The Cephalophora with which the sexes are separate, may be divided into two sections, in one of which, the copulatory organs are wanting, while in the other, they are highly developed.

1. To the first section, belong the Cyclobranchia, the Scutibranchia, and also, probably, the Tubulibranchia and Cirribranchia; with all of which, the genital glands are easily seen at the epoch of procreation, from the presence of sperm or of eggs.\(^{22}\)

\(^{22}\) The penis is short, and of a compact form with the Pteropoda; see the figures of that of Cymbulia, Tiedemannia, Hydroca, Cledora, Cuvieria, and Limmata, in Van Beneden, Exerc. zool. loc. cit. Clio, however, forms an exception in this respect, its penis being long and flexuous (Eckrich, loc. cit. Tab. III. fig. 24). With the Aplysia, this organ is pretty long, spiral-form, and concealed in a pyriform sac, and the Vas deferens is inserted at its base; see Altmann, loc. cit. Pi. VI. t. (Aplysia), and Nordmann, loc. cit. Tab. III. fig. 5, p. q. r. (Terepes). There is a similar disposition with Thetis, Tritonia, Doris, and Pteurobranchus (H. Mekel, loc. cit. Taf. XV.). In the last-mentioned genus, it is distinguished for its extraordinary length. That of Arion, Limax, Succinea, Lymnaea, Planorbus, Physa, Clausilia, Helix cellaria, and fruticum, is thick, very short, and unites either abruptly or gradually with the Vas deferens; while that of Bulinus, and most species of Helix, ends posteriorly in a long lush which projects freely into the cavity of the body, and upon which is inserted the deferent canal at a variable distance from the extremity (Fohalich, Treereaus, Erdt, Posch, loc. cit.). With Onchidium, Bulinus, and Gasteropodera, the penis has a very long, flexible mass, which, with Aplysia, and Pteurobranchus, is shorter, but never in connection with the Vas deferens (Cuvier, and H. Mekel, loc. cit.).

\(^{23}\) The retractors muscles are inserted at the posterior extremity of the penis with Arion, Limax, and Planorbus; and more in front and on the sides with Lymnaea, and Helix (Wohliche, Erdt, and Posch, loc. cit.).

\(^{24}\) Such a common genital orifice is found with Helix, Limax, Arion, Succinea, Bulinus, and Clausilia, on the right side of the neck behind the tentacles; it is situated further behind, but always on the right side, with Axolot, Terepes, Nythea, Doris, Tritonia, Thetis, Pleurobranchus, Pteurobranchus, and Diphylidium.

\(^{25}\) With Planorbus, and Physa, the male and female orifices are situated on the left side of the neck behind the tentacle; with Flabelina, Rhodope, Cledora, and Cuvieria, a little further behind on the right side.

\(^{26}\) With most of the Pteropoda (Clio, Cymbulia, Tiedemannia, Hydroca, and Limacina), the orifice of the penis is in the neck, and that of the genital cloaca a little further behind on the right side. With Actaeon, and Livosomus, the two orifices are also on the right side, but even more widely separated from each other. With Gasteropodera, Bulbus, Balbus, and Aplysia, the genital cloaca is very far behind, while the penis is under the right tentacle. With Doridium, the cloaca is also quite in the rear, but upon the left side, and consequently the penis is under the tentacle of the same side. But with Onchidium, these orifices are the widest apart,—the cloaca opening close by the anus, and the penis under the right tentacle. The burrow passing from the cloaca to the penis is found with all these Gasteropoda, and it is very probable that it will be found also with all the other Cephalophora, whose penis is entirely removed from the other male genital organs.

The burrow which Van Beneden (Exerc. zool. Fasc. II. p. 40) observed with a Hydidea, between the two genital orifices, shows that there is such a communication with the Pteropoda also.

The separation of the sexes with Chiton, Patella, and Holothurias, was first shown by R. Wagner and Erdt (Porier's t. Notiz. No. 249, 1839, p. 102). It has been confirmed with Patella, by Milne Edwards (Ann. d. Sci. Nat. XIII. 1849, p. 370), and by Robin and Lebert (Bid. V. 1846, p. 191). With many individuals of Vermiculus gigas, I have
In the genus Chiton, the male and female genital gland is long and lobulated; it lies over the other viscera, and, from each side of its posterior extremity, passes out a short excretory duct which opens upon the border of the mantle.\(^{(2)}\)

With Patella, and Halitosis, this gland is covered by the liver, and its single duct passes in front and opens near the anus, at the right with the first of these genera, and at the left with the second.\(^{(2)}\)

2. In the second section, there is a prostatoric penis with various Heteropoda, all the Pectinibranchia,\(^{(6)}\) and operculate Pulmonata.

The Ovary, or the testicle, always lies concealed at the base of the visceral sac between the liver, and its excretory duct, as Tuba Fallopri or Vas deferens, passes on to and accompanies the rectum during the remainder of its course.

The oviduct opens near and often a little behind the anus, and, with the Heteropoda, has frequently several glandular appendages;\(^{(3)}\) while, with the Gasteropoda, the portion accompanying the rectum is dilated into a kind of uterine tube which has glandular walls.\(^{(6)}\) From the walls of this tube are secreted, without doubt, the often very regular envelopes with which the eggs of many Pectinibranchia are surrounded.\(^{(7)}\) In this last-mentioned order, there has as yet very rarely been found an albumen-gland or a receptacle of the sperm which communicates with the uterus.\(^{(8)}\)

\(^{(1)}\) They are found, in the posterior region of the body, and in the greenish, or yellowish-brown glandular body, containing active spermatice particles, and very large canaliculae cells enclosing undeveloped spermatic particles, from which, passed off a long excretory duct opening near the anus, without the appearance of any penis. This apparatus is undoubtedly a male genital organ.

\(^{(2)}\) The other individuals, in which I could find no spermatic particles, were the females. The details by Ruppell (Mem. l. Soc. d'Hist. Nat. à Strasbourg, l. p. 3; fig. 4), and by Corus (L'hésem. de Seneck-enberg, l. p. 149), Taf. XII. fig. 8) upon the genital organs of Maja anciantis, render probable the separation of its sexes also; but it is doubtful if the male has a penis, as Ruppell says, for it is difficult to comprehend how coaptation can take place with this animal which lives buried in the coralline of the Madreporaria, any more than with the Verrucaria which are fixed upon stones. But Corus declares that he has seen, instead of a penis, a distinct papilla on the neck of Maja. The ovary, which, according to Descubes (loc. cit. p. 394, Pl. XV. fig. 8, 9, or Isis, 1832, p. 493, Taf. VII. fig. 12, 15) fills almost entirely the cavity of the body with Dentalium, will probably, after more careful research, prove, with many individuals, to be a testicle.

\(^{(3)}\) See Cuvier, Mem. loc. cit. p. 24, Pl. III. fig. 10, 13, or Isis, 1819, p. 734, Taf. XI. fig. 10, 13.

\(^{(4)}\) See Cuvier, Mem. loc. cit. p. 12-18, Pl. II. fig. 11, c. 14, 15, or Isis, 1819, p. 728, 731, Taf. XI. fig. 12, 14, 15.

\(^{(5)}\) The genus Littorina is the only one which contains hermaphrodite species; here the volutions penis, having a longitudinal furrow, projects under the right tentacle (Quoy and Gaimard, Voy. de l'Astrolabe, Zool., or Isis, 1834, p. 290).

\(^{(6)}\) The genital organs of the Heteropoda are yet imperfectly known, and what has been said in the text relates only to Carinaria. Among the two or four deep-colored appendages of the vagin of Carinaria mediterranea, may be especially distinguished a spermatocoele containing internally transverse glandular folds (see Dela Cigale, Memor. II. p. 208, Tav. XVI. figs. 5, 6, and Descrip. II. n. 97). These appendages, the existence of which I have verified with individuals preserved in alcohol, must be more carefully studied before it can be decided if they are the analogue of an uterus, seminal sac, &c.

\(^{(7)}\) See Cuvier, Mem. loc. cit. fig. 2, 3, h. Tre- viranus, Zool. i. Physiol. l. p. 38, Taf. IV. fig. 21; Passel, in Wiegmann's Arch. 1844, l. p. 100, Taf. V. fig. 8 (Paludina vinipara) and Leiberin, in Hensinger's Ztscl. I. p. 52, Taf. I. fig. 6 (Mu- reus). Quoy and Gaimard have furnished many facts on this point (loc. cit., or Isis, 1834, 1836). With Strombus fimbrius, they have described a bur- row which arises from the female genital orifice, and passes along the right side of the foot.

\(^{(8)}\) These envelopes or capsules filled with eggs are cylindrical, perforated, intususceptiform, and sometimes polychromated. They are attached singly to objects, and many times are aggregated in considerably sized masses around a common axis. Often they open by a special fissure, which, in some species, has a particular operculum; see Land, in Ann. d. Sci. Nat. l. 1834, p. 84, Pl. VI., or Frosteig's Nat. l. 1834, 1834, and D'Orbigny, in Ann. d. Sci. Nat. XVII. 1842, p. 117. Such a mass, arranged around an axis, in which the eggs of Minthea are deposited, and which is carried about with them a long time attached to their foot, was long regarded as an enigmatic body under the name of Spuma coniuncta, and, by some naturalists, has been even considered as a modified operculum of the shell; see Land, loc. cit. fig. 25; Lesson, in the Voy. de la Coquille, Zool. II., or Isis, 1833, p. 134, Taf. I. fig. 1; and Dela Cigale, Descrip. II. p. 105, Tav. LXVII. fig. 1, 2.

\(^{(9)}\) With Patula tricolor, there is an abundant gland beneath the last convolution of the intestine (see Treveroum, loc. cit. p. 31, Taf. IV. fig. 21, u, and my observations in Muller's Arch. 1836, p. 243). In this same species, the bottom of the uterus communicates by a large orifice with a sessile Re- cepaculae stellata with which I have always found, after consideration, a conspicuous active spermatic particles (Muller's Arch. 1836, p. 244). This sac for fecundation appears to be absent with all the other Pectinibranchium, and Sterkity (Zool. Jour. II. 1823, p. 278, or Isis, 1839, p. 1249) could not find it with the females of Cyclosterones.
The course of the seminal duct, and that of the oviduct also, is the same as that of the uterus, until it reaches the extremity of the rectum, when it passes into the penis which always projects from the right side of the body. With the Heteropoda, the penis is often bifid, but then the seminal canal does not traverse except one of its divisions. 9

With the Gasteropoda, the penis is either very long, 10 tongue-shaped and often flexuous, 11 or short and lanceolate. 12 It projects under and usually behind the right tentacle, and extends upon the side of the body — rarely being in a wholly retracted state, but is capable of being easily folded under the border of the mantle.

With some genera, its extremity has a small hook. 13 With several Pectinibranchia, the seminal canal terminates behind the anus, and then takes the form of a furrow, which communicates with the base of the penis, extending even to its extremity, either as an external, or an internal seminal. 14

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The development of the Cephalophora has, as yet, scarcely been observed except with the Gasteropoda, and in particular with the Apneusta, the Heterobranchia, and the Pulmonata. 15

All observations concur as to the fact that the vitellus undergoes a regular and complete segmentation, 16 after which, there appears an usually long, round embryo, one of the poles of which is indented and covered with

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9 The penis is double and on the right side at the base of the visceral sac, with Cardiaria and Pterotrachea (M. Edw., Ann. d. Sc. Nat. XIII. 1840, p. 156, XVIII. p. 323, Pl. X. fig. 5). Quoy and Gaimard (Voy. de l'Arctique, Mollusq. Pl. XXVIII. fig. 10, or Isis, 1834, Taf. III. fig. 10) have figured a long bifid penis with Phylliloric anboinensis; and as if with the other Heteropoda the penis is not retractile, as appears to be the case with Cardiaria, according to M. Edw., this species would be a male, while Phylliloric knowlisis, figured by Peron (Ann. du Muséum XV. fig. 1, or Kosse, De Pterotrachea ord. Dis. fig. 1), apparently without a penis, would be a female; although D'Orbigny (Voy. dans l'Amer. mérid., or Isis, 1853, p. 514) regards this genus as hermaphrodite. With Atlanta, there is a simple, pointed penis on the right side of the neck directly near the arms; but as Keng (Mon. loc. cit. p. 579, Pl. IX. or Isis, 1832, Taf. VII.) has found this penis with all the individuals he has examined, it may be questioned if the sexes are really separate with this Heteropoda.

The internal genital organs of Atlanta, and Phylliloric, should be thoroughly studied for the elucidation of this point. 17

10 For the male genital organs of the Pectinibranchia, see especially the works of Cuvier, and of Quoy and Gaimard, loc. cit.

11 Bucephalus, Muræx, Dolium, Harpa, Ampullaria, Melia, Litotracea, Strombus, Cystocheta.

12 J. Quoy, Eoures, Conus, Sc. C. Cassis, Dolium, Bucephalus, Strombus, Sirena, and Paludina. With Pulmonaria, the penis is, moreover, so united to the right tentacle, that this last appears to be detached prolongation from the inferior surface of its apex (Trechéros, loc. cit. Taf. IV. fig. 12).

13 With Dolium, Harpa, Ampullaria, Tritoniium, Strombus, Sc., this semi-oval extends even to the end of the penis (Quoy and Gaimard, loc. cit.); while with Muræx, it ceases at the base of this organ (Leeslitz in Heusinger's Zeitsch. I. p. 31, Taf. I.).

14 With the Cephalophora, the embryonic development does not generally begin until after the eggs have been deposited. A few only of the Gasteropoda, and among them Paludina vivipara, and Clamellia ventricosa (Heil, Isis, 1854, p. 1001), are viviparous.

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a delicate ciliated epithelium. By the means of these cilia, the embryo rotates upon its axis for a long time. From this period, the aquatic differ widely from the pulmonate Gasteropoda. With the Apneusta, and the Hetero'branchia, the two lo'ules produced by the indentation just indicated, enlarge and change into round pinions (Vela), upon whose borders very long cilia are gradually developed. A third eminence is developed between these two pinions, and, ultimately, changed into the foot.

Although the ciliated epithelium is always most widely spread around these two pinions, which should be regarded as situated on the anterior extremity of the body, yet there is formed a thin shell upon the posterior extremity of the embryo, whether this last belongs to a conchiferous species or not. At the same time, there appears upon the dorsal part of the foot, an operculum corresponding as to size with the opening of the shell.

Among the internal organs, the two auditory capsules appear first; and when these have become quite distinct, the eyes are seen. Following these, are developed the tentacles, the border of the mantle, and the mouth which appears between the two pinions. At the same time, the stomach, the intestine, and the liver, individually appear in the interior. At this epoch, the young leave the egg and swim freely about by means of the long cilia which are situated on their extended and rigid pinions. Subsequently these pinions disappear, or are changed into two tentacular prominences situated on each side of the mouth. At the same time, also, the naked Gasteropoda lose their shell and operculum. From the isolated facts hitherto published upon the embryology of other branchiferous Gasteropoda, it may be concluded that they experience a similar metamorphosis, only the shell of the embryo, at this time, usually presents some convolutions.

In the development of the operculate Pulmonata, there is no analogous metamorphosis. The embryo lengthens a little when it begins to rotate

bo, Nerita, Bucephalus, and Pupinema. Judging from Carus' figure (Nov. Act. Acad. Nat. Cur. XIII. 1827, p. 707, Tab. XXXIV. fig. 2) of the embryo of Petrudia cirripetifera, it also has at this age a pinion.

This remark is also applicable to the young animals found by Land (Ann. d. sc. Nat. 1. 1834, Pl. VI. fig. 9-14) in the egg-capsules of a Murex () and a Natica (?). I have found, in the pyriform ovigerous capsules adhering to the orifice of the shell of Vermetus, young with highly-developed pinions having long cilia, and with a regularly convoluted shell, such as has been described by Phillips (Wiegmann's Arch. 1839, p. 129, Tab. IV. fig. 8). Loven has observed similar embryos swimming with two pinions, with the Hetero'branchia of the genera Elphita, Buita, Bulboidea, and with the Pectinibranchia of the genera Lmna, Cerithium, and Eulima; see Arch. Skad. Acad. Beitr. & c. I. 1846, p. 154, Tab. I. fig. 1-5.

The development of the Pulmonata which have a shell, has often fixed the attention of naturalists. See Stiebel, loc. cit. p. 58, Tab. II. and in Meer-See-And. d. sc. Nat. 1. 1834, Pl. 423, p. 567, Tab. VI. 1. Hugi, Isis, 1824, p. 233; Carus, von den ammonischen Lebensch. loc. cit. p. 96, Tab. I. 1. Pervatius, Ann. d. sc. Nat. 1. 1834, p. 30, the genus Cyprer. groser, and Phasianella. The small Mollusks with a pyriform shell, of which Sars (Beskr. av. sc. Nat. 1. 77, fig. 39, 35) has formed this curious Cephalopoda, have since been found by himself, to be young individuals of Turbo, Puchon, or Nerita; this accord with Grant's observations (Edinb. new Philos. Jour. No. 15, 1827) upon Tur-
up on itself; its posterior extremity soon assumes a spiral form and is covered with an alveolate wrapper, upon which gradually appear the convolutions of the shell, without there being formed, at the same time, an operculum. During this period, the eyes, tentacles, border of the mantle, and the foot, appear at the anterior extremity; and, in the interior, the auditive capsules, the intestinal canal, the liver and heart are gradually developed. Here, therefore, the development of the cephalic pinnions, which characterize the embryos of the Branchiata, is also incomplete.

The development of the naked Pulmonata is quite different. When the round embryos begin to rotate, two cestre appear side by side, upon the previously divided vitellus; one of these is changed into the shield and into the respiratory and circulatory organs situated beneath, while the other goes to form the foot. At its anterior extremity, appear the eyes, tentacles, and lips; and at the posterior extremity, a peculiar contractile vesicle is formed. This vesicle presses its contents towards the vitelline substance which is still contained in a kind of vitelline sac projecting anteriorly between the two cestre, and which, also, becomes contractile. By this arrangement there is an interchange of the contents of the vitelline sac and the caudal vesicle, due to their alternate contractions. Subsequently, the liver and digestive canal are formed out of the vitelline substance between the two cestre. The vitelline sac and caudal vesicle are in this way considerably diminished, and, at last, wholly disappear.

The development of Sagitta, as far as yet known, differs essentially from that of the Gasteropoda, in that its embryo is not formed at the expense of the Limacina, for Gephyrid (Ann. d. Sc. Nat. XVII. 1857, p. 374, or, Observ. sur Mollusca. Athas, 1842, Pl. V. fig. 10, 11) has seen in the eggs of Lin- max cinereus soon after their deposition, singular vitelline movements exactly resembling the alternate protrusions and retractions of the parenchyma of Amoeba.


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\* This contractility shows itself quite early in the
of the entire surface of the vitellus, but surrounds the last in a ring-like manner, and is gradually detached by its cephalic and caudal extremities.

pacious portion are found both male (testes), and female (ovarium) organs in the shape of sacs, which are not attached in any way to the main mollusckigerous sac. These genital organs bear no resemblance whatever to ordinary testes or ovaries, except in their products, which are identical. When the ovarium is perfectly developed, it and its capsule burst and discharge the ov a which are then contained in the main mollusckigerous sac; after this, fifteen to twenty ovar become invested with a common capsule, though their formation takes place previous to this investment. Upon this succeeds their development.

The sperm-capsules vary from four to eighteen in number, and lie perfectly free in the main sac, not far from the ovary. The spermatic particles are set free by the bursting of these capsules, and they resemble those of the Gasteropod Mollusk in shape and form.

The development in the egg here proceeds exactly as with the Mollusca (e.g., Acteorn, according to Vort), and finally it assumes pretty definite characters indicating rather its relation to the Pectinibranchia. Of its zoological character as a Mollusk there can, therefore, be no doubt, and the whole story in a word is, that a true Mollusk is developed within a Synapta, not by generation, but by means of the normal sexual products which occur under otherwise anomalous and anomalous parts and conditions. It should, moreover, be remarked that the connection of this mollusckigerous sac is not special or direct with the Synapta, but this last appears to serve as a kind of nest in which the Mollusk carries out its anterior and remarkable changes.

Such being the facts, the question now arises, What interpretation shall be given these phenomena? The distinct sexual mode of reproduction would seem to remove these phenomena from the category of the so-called alternation of Generation, or geminarity as we now understand it. Then again, the doctrine of "heterogeneous generation" as suggested by Malter, does not seem to me admissible, beside being particularly unsound,— for if an animal can produce, by true sexual generation, an offspring zoologically dissimilar to itself, zoologists may well look about for the stability of their science. If I may be allowed an opinion or rather a view on a subject on which I have made no observations, I would say that an approximate solution of this enigma seems obtained by admitting the possibility of new and hitherto unknown parasitic conditions in the life of the Mollusk in question.

Why may not this Mollusk undergo a form of retrograde metamorphosis during which its life is parasitic and very peculiarly connected with the life of another and wholly different animal? Or again, why may not the phenomena observed in Helix, under conditions of certain low modes of life which are connected with points in the economy of these animals that we do not yet understand? I throw out these remarks in a suggestive way. If we refer for a moment to the historical relations of the Cestodes, it will be perceived that there was a time when the conditions of their life were equally if not more obscure. Siebold, however, has shown that here, although the path taken by Nature is circuitous and intricate, yet, after all, no new features of a heterogeneous nature are introduced, and that all required for the observer was care and patience. It does not seem to me any more improbable that this Mollusk should have entered in some of its stages the body of the Synapta, since the anomalous undeveloped forms of many Helminthes pursue a similar course. Let the naturalist also bear in mind the remarkable phenomena of the Hexoctyli. In the Nachtrag to this first account before the Berlin Academy, but more especially in a subsequent and more complete account (Ueber die Eier der Schnecken, in Müller's Arch. 1852, p. 1) lately given, Malter discusses still further these facts. After some remarks upon the importance of a careful study of the embryology of this curious form, he says: "I do not give up the hope that we may yet determine at least the genus of this Mollusk; and I found this hope mainly upon the very characteristic form of the spermatic particles, besides the other features above mentioned. . . . . . . The spermatic particles of Natiea and its allies are yet unknown. . . . . . . In studies bearing upon this matter, one should particularly bear in mind the terminal enlargement of the spermatic particles, which up to this time has been observed in no Gasteropod, but which with the spermatic particles of the Mollusk in question is never wanting." Although for some time familiar with the details of the spermatic particles of the Gasteropod Mollusks, yet I have very recently re-examined the spermatic particles of Natiea (N. heros) with reference to this point. They resemble closely those of the pulmonary Gasteropoda (Helix, for instance), and consist of a well-defined cori-screw head to which is attached a very delicate tail; they agree, therefore, in general with the form given by Malter of the Mollusk in question.—En.
BOOK ELEVENTH.

CEPHALOPODA.

CLASSIFICATION.

§ 230.

The Cephalopoda present, in their organization both internal and external, so many peculiarities which distinguish them from all the other Mollusca, that it is necessary to consider them in a class by themselves, although their genera are not numerous.

It is, moreover, necessary to state why we here regard the different forms of Hectocotylus which hitherto have been considered as parasites of these animals, as the males of certain Octopoda. The researches of Kölïker have led us to make this change. This naturalist founds his opinion upon the following convincing reasons: The specimens of Hectocotylus have branchiae, and a heart with arteries and veins, and they cannot, therefore, be regarded as Helminthes. On the other hand, they have, in common with the Cephalopoda, the contractile chromatophoric cells of the skin, and the same kind of seminal particles and suckers; and the muscular substance of their body is arranged exactly like that of the arms of the Cephalopoda. All of them are males, and the Cephalopoda, with which they are connected, are all females; finally, the embryos found in the eggs of certain Octopoda exactly resemble them. Whoever has had the opportunity of examining the species yet known, viz: Hectocotylus argonautae, octopodis, and tremoctopodis.

1 At present there are known two or three species of these singular beings resembling the torn-off arms of the Octopoda, and which live in the cavity of the mantle of certain Cephalopoda, attached by the means of suckers. Hectocotylus argonautae was first described quite imperfectly by Delhe Chiage (Monogr. &c. 11, p. 223, Tav. XVI. fig. 1, 2, and 16, 17, 1832, Taf. X. fig. 12, a, b.) under the name of Triacrophalus acetabularis. Another description by Costa (Ann. d. Sc. Nat. XVI. 1844, p. 186, Pl. XIII. fig. 2, a, c.) has not added much to our knowledge of the real nature of this animal. Another species, Hectocotylus octopodis, established by Cariner (Ann. d. Sc. Nat. XVIII. 1827, p. 147, Pl. XI. A. fig. 1, 5, or Froger's Nat. XXV. 1828, p. 6, fig. 16-18, or Isis, 1852, p. 653, Taf. X. fig. 1-5) should be found in the cavity of the mantle of Octopus granulosus (Lamarck). It is probably identical with Octopus tuberculatus of Delhe Chiage (Octopus Verany, Wagner), which lives in the Mediterranean Sea, and perhaps, also, with Tremoctopus violaceus. If this last is not so, there is then a third species of Hectocotylus, viz: the male of Tremoctopus violaceus.

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dis, as well as the females on which they are found, will admit the cor-
rectness of the preceding statement, and, also, must have perceived the very
remarkable abortiveness of the males of Argonauta and Tremoctopus.3

**Family: Nautilina.**

**Genera:** Nautilus, Spirula.

**Family: Octopoda.**

**Genera:** Argonauta, Tremoctopus, Octopus, Eledone.

**Family: Loligina.**

**Genera:** Sepia, Loligo, Onychoteuthis, Sepioteuthis, Ommastrephes, Loli-
gopsis (Perotis), Cranchia, Rossia, Sepiola.

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3 I am indebted to Kölliker for the examination of these individuals of Hectocotylus tremocto-
podis, of which I found two in one and the same cavity of the mantle of a female. Although they have been preserved in alcohol a long time, yet I was able to assure myself of the correctness of many of Kölliker's statements, and thereby to be convinced of the real nature of these animals.*

* [§ 230, note 3.] See my note below under § 251, note 6. — Ed.
THE CEPHALOPODA.

§§ 231, 232.

ADDITIONAL BIBLIOGRAPHY.


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CHAPTER I.

INTERNAL SKELETON.

§ 231.

The Cephalopoda have many cartilages, which, serving as points of insertion for muscles, and surrounding the nervous centres, may therefore be regarded as the rudiments of an internal skeleton.

Their texture is essentially the same as that of the true cartilages of the vertebrata. There is a homogenous, usually yellowish base, having the aspect of ground glass, in which are scattered numerous dark-colored molecules. This base contains, moreover, the proper cartilage cavities, which enclose a mass of granules, and each a more or less distinct nucleus. These cavities are more or less numerous, and are often partitioned each into two by a thin septum.

§ 232.

These rudiments of an internal skeleton may be divided into the cephalic, dorsal, articular, branchial, and pinnate cartilages.\(^1\)

I. The Cephalic cartilage is concave in front and convex behind. It is perforated in the centre by the oesophagus and by two lateral conchoidal prolongations. At its upper part there is a deep excavation for the reception of the brain; and, at the inferior part, an enlargement containing the auditive organs. It is, moreover, traversed by canals of different sizes for the passage of nerves. The two lateral prolongations cover, by their anterior and concave surface, the ocellar bulbs, and are thus the analogues of a kind of orbits. With Loligo, and Sepia, there are, beside, two lanceolate, cartilaginous lamellae, which join with the anterior and inferior parts of the cartilage, covering the ocellar bulb in front, and thus completing the orbit. Nautilus differs very much from the other Cephalopoda in this respect. The lateral prolongations are wanting, and the body, which is incomplete above, is much developed below, and has two prolongations extending in front in a forked manner and concealing the auditory organs.\(^2\)

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2 See Owen, On the Nautilus, p. 16, Pl. VIII. fig. 1, or Isis, 1835, p. 12, or Ann. d. Sci. Nat. XXVIII. p. 102, Pl. IV. fig. 1, and Valenciennes, loc. cit. p. 271, Pl. IX. fig. 4, 6.


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2. The Dorsal cartilages are found only with Sepia and Loligo. They are two in number; the inferior is situated in the neck, and the superior in the mantle at the anterior extremity of the internal shell. The cervical cartilage of Loligo is very long, rhomboid, and pretty massive; while that of Sepia consists of a thin, semilunar plate, with the cavity directed backwards. In both genera, its median line has a longitudinal groove; and in both also, the superior cartilage is only a thin semi-lunar lamella, both extremities of which are extended backwards by a long prolongation.

3. Those are called Articular cartilages, which, with Argonauta, and the Loligina, are found on each side of the base of the funnel, in the form of long cupels whose cavities receive, when the mantle is closed, the two cartilaginous prominences of its (the mantle's) internal surface.zial

4. The Brachial cartilage is found only with Sepia. It is a narrow plate, transversely situated directly in front of the superior border of the cephalic cartilage. It has, anteriorly, three short apophyses for the support of the base of the arms. With the Loligina, there is found in the mantle, at the base of the lateral fins of the body, two other narrow lamellae,—the Fin-cartilages; these serve as points of insertion of the musculus of the fins, and extend more or less along the sides of the body, taking the form of the fins.

CHAPTER II.

CUTANEOUS ENVELOPE.

§ 233.

The Cephalopoda are distinguished from the other Mollusca by a wholly peculiar structure of their skin. The skin is easily detached from the subjacent muscular layer, to which it is united by a loose cellular tissue, the fibres of which are interlaced in every direction. The extremely thin epithelium of the skin is lamellated, but never ciliated, with the adult individuals. The Corium is composed of a contractile fibrous tissue, in the meshes of which are contained the remarkable contractile Chromatophoric cells. These consist of flattened, contractile cavities surrounded by a very

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3 See the figures of Förussar, loc. cit. (Sepia, Sepiola, and Argonauta). With Argonauta, the two projections of the mantle are round cuberces, while with Loligo, Onychoteuthis, and Sepiola, they are two very long longitudinal ridges, to which corresponds a groove-like excavation in the two oppositely situated cartilages of the funnel.

By means of these articular cartilages, together with the two dorsal, when present, the collar-like border of the mantle is exactly fitted about the neck of the Cephalopoda.

The cartilages of the fins are very long with Sepia (Schulzer, loc. cit. fig. C, D), and Owen,

4 [§ 233, note 1.] I have made some careful observations with the microscope upon the chromatographic relations of the skin of the Cephalopoda, selecting for Cyclop. loc. cit. fig. 212, D, D, but very short with Sepiola.

5 For the chromatic cells, see San Giovanni, in the Giornale enciclopedico di Napoli Ann. XIII. No. 9, or Freycinet's Nat. V. 1825, p. 215, or Ann. d. Sc. Nat. XVI. 1829, p. 565; Freycinet, Obser. sur la mobilité des taches que l'on remarque sur la peau des Céphalopodes, &c., Paris, 1823; Delic Celine, Mem. loc. cit. IV. 1824, p. 65, and Desoria, l. 1841, p. 34; Wagner, Isis, 1835, p. 150, in Wiegmann's Arch. 1841, l. p. 35, and Icon. zoot. Tab. XXIX. fig. 8-15, and Harters, in Wiegmann's Arch. 1844, l. p. 94, Taf. L.
delicate elastic membrane; when contracted, their form is round, but it becomes dentate on dilatation. The pigment granules, which they enclose, are always of the same color in each cell, and produce the red, the yellowish-brown, the blue, or violet spots, whose extent and shade vary, according as the cells are contracted or dilated. Usually, adjacent cells have very different colors, and to their alternate contractions and dilatations in groups, are due those magnificent chromatic changes which have long made celebrated the skin of the Cephalopoda.

These contractions, and consequently these chromatic changes, are under the influence of the nervous system. This is the reason of their decrease or disappearance, or their reappearance and increased brilliancy, in certain places, when the neighboring or even the distant skin is irritated. Moreover, the fibres of the corium preserve their contractility after having been detached, so that the chromatic changes may be observed on portions of the skin that have been removed.

§ 234.

Behind the neck of the Cephalopoda, the skin forms a large sac-like mantle, which completely envelopes the trunk, but is adherent only upon the back. Its anterior border is free, and can embrace, like a sphincter, the neck and posterior part of the head. Under the throat, the skin is prolonged in the form of a funnel, the free apex of which extends in front, while the broad base communicates with the cavity of the mantle, and is

2 The movements of the chromatic cells are not directly due to the cell-membrane, but to the contractile fibres of the dermis which are united in them, and which, upon contraction, pull at their point of insertion, thus producing the ragged aspect of these cells when expanded. They return to their round form when the fibres are relaxed, from the elasticity of the cell-walls (see Kutilber, Berwick, d. Cephalopoden, p. 71, and Hartless, loc. cit.). When these cells are dilated, the pigment granules are often removed from the centre to the periphery of the cell, thus forming a central, colorless transparent spot, which has been regarded by Wagner (loc. cit.) as the nucleus of the cell.

3 These so highly characteristic chromatic cells of the Cephalopods, are found also in the skin of Hectocotyla, and are, therefore, one of the data for determining the nature of these animals, which have hitherto been regarded as trematode parasites. Delitz Chanie and Costa (loc. cit.) have represented these cells in a colored figure of Hecto- cotyla argonautae. I have, also, distinctly seen them with individuals of Hectocotyla trematopoda preserved in alcohol.

As Grabe (Abkén. Echihinornern und Würmer des Adrîtt. und Mittel-Meeres, p. 43, fig. 2) has observed these same chromatic cells in the skin of a genus of parasites, which he has called Pup- pus charmeleon, it is certain that this animal, found on the branchiae of a marine fish, is only a form off arm of one of the Cephalopods. The presence of these cells in the skin of Nautilus proven, for Runph (Amboinsche Karakten-Kamer van Schoneuren und Museelen, p. 7) expressly declares of this animal which he saw living, that "its upper portion is reddish or bright brown with some black spots, which, with its cuttle-fish, become faded." The fragment of the Medusa, which Quay and Gaimard found at the Celebes islands, and which they thought to belong to Nautilus pomipillus (Ann. d. Sc. Nat. XX. 1830, p. 470, Pl. XIV. A. or Isis, 1831, Taf. XV. A. B.) deserves our attention in various ways. If it really belonged to a Cephalopod, it should have the chromatic cells, a point which may yet, perhaps, be determined from the preserved specimen at Paris. In the colored figure which these naturalists have given of it, the skin is dotted with red,— a presumption in favor of the existence of these cells.

But, indeed, is it not possible that this animal, from its resemblance to the Hectocotyla, is not a multi-tubed one, but the male of Nautilus pomipillus, abortive as to its form and size?
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covered by its anterior border. The sea-water, which enters into the interior of the mantle, passes, with its various contents, into this funnel, and is thence expelled through its anterior orifice.

Many Cephalopoda have, on the dorsal wall of this organ directly behind the anterior orifice, a tongue-shaped valve, which prevents the reflux of the water.

With the Loligina, the sides of the trunk have variously-shaped cutaneous lobes, which these animals use as fins. The Octopoda, on the other hand, swim by rowing with their arms, which are bound together at their base by a kind of natatory membrane, whose extremities have, each, a broader or narrower cutaneous dilatation.

§ 235.

The mantle of many of the Cephalopoda secretes a shell, which may be either external or internal.

1. An external shell is found with Argonauta and the Nautilina. That of the Paper-Nautilus is very thin and flexible,—and, in its composition, the organic base predominates above the calcareous matter, which consists of thickly-set, small, round masses. The substance of the shell, which, with Argonauta, is nowhere attached to the animal it encloses, is secreted principally by the two large cutaneous lobes of the two median dorsal arms, which lie upon the external surface of the shell. On this account, the structure of the two surfaces of these lobes is different;—the external surface is quite smooth and has many chromatid cells; while the internal has scarce any of these last, but is covered with numerous reticulated, projecting lines, which become the more prominent when the lobes are contracted, and between which, cell-like depressions are formed.

With the Nautilina, the shell has a very complicated structure; its walls are composed of two distinct layers, clearly separate, the internal of which has a beautiful mother-of-pearl aspect. The cavity of the shell is divided, even to the last spiral turns, by numerous transverse septa, which are all perforated. With Nautilus, a tube traverses the septa, while with

1 With Nautilus, the funnel is composed of two pretty large, cutaneous lobes, placed upon both sides of the throat, and reciprocally covering each other on the ventral surface in a corset-like manner; see Owen, On the Nautilus, p. 10, Pl. I. or Isl. p. 19, or Ann. d. Sc. Nat. loc. cit. p. 93, Pl. I. III. and Valenciennæ loc. cit. p. 269, Pl. X. fig. 1.

2 This is so with Sepia, Sepiola, Loligo, Sepioteuthis, Onychoteuthis, and Nautilus. For this last, see Owen, loc. cit. Pl. II. fig. 2, e, and Valenciennæ, loc. cit. Pl. XI. fig. 4, 2. I have sought for it in vain with Argonauta, Eledone, and Tremoctopus. It is also wanting with Loligopus and Cranchia; with Octopus, there exists in its place, that is, on the ventral surface of the funnel, a transverse ridge.

3 With Sepia, and Sepioteuthis, both sides of the body are bordered their entire length with a cutaneous lobe. With Loligo, and Onychoteuthis, the two fins are triangular and inserted on the posterior extremity of the body; they are round and short with Sepiola, Loligopus, and Cranchia; in the first of these genera, they are situated on the middle of the sides of the body, and in the last two, upon its extremity.

4 These interbranchial natatory membranes exist with Octopus, Eledone, and Tremoctopus; they are particularly developed in this last genus, between the two pairs of dorsal arms.

In this same genus, as also with Argonauta, the two dorsal arms are terminated by a very large cutaneous lobe, and are used not only as locomotive organs, but also for keeping the shell in place by being applied on its external surface; see Ferrussea, loc. cit. Argonauta, Pl. I. fig. 5, G, Pl. VI. fig. 2, and in the Mem. de la Soc. d'Hist. Nat. de Paris, I. 1835, p. 160, Pl. VI. fig. 2; or Isl. 1832, p. 460, Taf. V. fig. 2; Rang, Docum. pour servir à l'Hist. nat. des Céphalopodes, in the Magaz. de Zoöl. 1837, Livr. IV. p. 19, Pl. LXXXVII., or Ann. d. Sc. Nat. VII. 1837, p. 170; and Delle Chiaie, Descriz. loc. cit. Tav. VIII. fig. 3, 2.

1 It has been asserted by several observers, that these two cutaneous lobes furnish the substance of the shell, and that, also, with which the animal repairs accidental lesions; see Rang, Magaz. de Zoöl. loc. cit.; Jeanette Power, in the Atti dell' Acad. di Scienz. Nat. di Catania, XI. 1830, or Isl. 1845, p. 665; and in Wiedmann's Arch. 1845, I. p. 369; and, further experiments and observ. on the Argonauta Argo, in the Report of the Brit. Assoc. 1844, Notices and Comunications, p. 74. For the non-paraesthesia of the animal, see, moreover, Van Beneden, loc. cit. p. 4, and Fernau, loc. cit. p. 114.

Spirula, an analogous calcareous tube extends close upon the inner surface of the shell from one septum to another. The animal, whose trunk occupies only the first chamber, is loosely attached to it by the cartilaginous border of its mantle.

With Nautilus, this border has a lobe which extends along the back of the animal, surrounding the spiral portion of the shell. With all the Nautilidae, there is another prolongation in the form of a membranous tube, or Siphon, which arises from the posterior part of the body, traverses the orifices or calcareous tubes of the septa, and penetrates even into the last chambers of the shell. These chambers are lined with a thin membrane, and have no external communication except through the Siphon.

2. With the Loligina, an internal shell lies free in the dorsal portion of the mantle. In most genera, it is composed of a homogeneous, horny substance, of a yellowish-brown color, and has a form like a feather (Calamus), or the head of a lance. At one of its extremities is an attenuated stem, and two delicate lateral winglets of variable length. With Sepia, this shell differs very much from that of the other Loligina. Its two surfaces are covered by very distinct calcareous layers, which have erroneously given it the name of Os sepiae. As a whole, it is tongue-shaped; its two surfaces are convex and its borders are sharp. Behind, the lateral borders become thinner and are slightly bent toward the ventral surface; and a short conical point projects from the middle of the posterior border. The horny substance is reduced to a thin sheet, situated between the calcareous layers, but its borders usually extend out beyond those of these last. The calcareous layer of the dorsal surface is very thin, but quite solid, and its surface in front, is granulated and striated; that of the ventral surface, on the other hand, is very thick, especially in the middle, and its very loose tissue contains numerous quite thin, porous lamellae, which, superposed almost horizontally, alternate regularly with layers of small, transversely-striated, dichotomous, vertical prismns. This ventral layer is truncated obliquely from its middle backwards, and the horizontal layers may easily be counted upon its truncated surface.


5 See Wagner, loc. cit. Tab. XXIX. fig. 32 (Loligo), and Ferussac, loc. cit. (Loligo, Loligo, Loligo, Oxychoteuthis, Sepiola, and Sepioteuthis).

I cannot here omit speaking of the remains of an antediluvian animal, which, under the name of Aptychus, has much engaged the attention of palaeontologists, and, up to the present time, been the object of discussion.


This last opinion is undoubtedly the correct one. As for myself, I am able to perceive in the different species of Aptychus only shells whose shaft is abortive, and the wings excessively developed. I was therefore quite surprised to hear my colleague, Alexander Brown, express himself in a conversation, that, after all, the animal called Aptychus might well have been the male of certain Ammonites. If the relations of the Hectocotyls to certain Octopoda are borne in mind, the idea of Brown, that there have existed Ammonites, the males of which are quite different in form from the females, certainly merits much consideration. For the males of these animals were, perhaps, abortive, like those of Argonauta and Terebactopus, and obliged, therefore, to shelter themselves in the mantle of their females, and this would explain why it is that the specimens of Aptychus are so often found at the base of the first chamber of Ammonites.

Judging from the form of the shell, the bodies of these animals must have been very large. There will be an additional analogy in favor of this view, if it is proved that the large and flattened animal found by Quoy and Gaimard is really the male of a Nautilus (§ 233, note 3).

6 The error of Spix (Cephalogenesis, loc. cit. p. 57) in comparing it to a rudimentary vertebral column, is still wider.

7 According to Kuhlker (Entwickel. loc. cit. p. 52), in comparing it to a rudimentary vertebral column, is still wider.

8 A very detailed description of this Os sepiae has been given by Cuvier (Mem. loc. cit. p. 46), Brandt (Mém. Zool. 11, p. 300, Tab. XXXI. fig. 5, 6), Wagner (loc. cit. Tab. XXIX. fig. 54), and Ferussac (loc. cit.).
Although it must be supposed that the calcareous matter of this shell is secreted by the internal surface of the dorsal cavity, yet the thin fibrous membrane which lines this last, is without a glandular structure.

CHAPTER III.

MUSCULAR SYSTEM AND ORGANS OF LOCOMOTION.

§ 236.

The muscular system of the Cephalopoda is highly developed. Its primitive fibres are smooth, but are not so diversely interlaced as with the other Mollusca. These fibres are usually parallel, and the fasciculi which they form, are of equal thickness. When isolated, they often show a zigzag tendency, which, probably, belongs also to their state of contraction. The fasciculi are very compactly bound together in one direction by a cellular tissue, and, in this manner, form clearly-defined, long, flat muscles.

§ 237.

The mantle of the Cephalopoda has a very distinct layer of circular fibres.(1) From the internal surface of the sac which it forms, arise, in the dorsal region, two pairs of large cylindrical muscles. One pair of these passes in front and is extended into the walls of the base of the funnel; the other pair extends to the posterior part of the neck, and is inserted partly into the cephalic cartilage, and partly at the base of the arms. The other muscles, which are thinner, arise from the sides of the cephalic cartilage, and are inserted upon the funnel.(2) By means of a part of this muscular apparatus, these animals can vigorously contract the cavity of the mantle and the funnel, and, by tightly embracing the neck and base of the funnel with the border of the mantle, can eject, through the orifice of this last, the liquids contained in the cavity of the body. With many species, these muscular contractions serve, also, as a means of a backward locomotion in the water.

§ 238.

The principal locomotive organs of the Cephalopoda are the arms fixed upon the cephalic cartilage; they serve also as prehensile organs. Each of these consists of a tubular axis composed of a dense cellular tissue, of muscular fibres radiating towards the surface, between which are inter-

1 This muscular layer is incomplete with Sepia — being wanting in the dorsal portion of the mantle.
2 A very full description of the muscles of the trunk and the head of Cephalopoda may be found in Cuvier, loc. cit. p. 9; Brandt, loc. cit. p. 303, and especially in Delle Cangi, Memor. IV. p. 74, and Desérès, &c., I. p. 21.
posed others which are longitudinal, and, lastly, of a layer of circular fibres directly beneath the skin. (6)

Over the entire length of the internal surface of these arms, are suckers, arranged in a single, double, or multiple row. (2) But with the Loligina, these suckers occur in groups of variable extent only at the extremity of the ninth and tenth arms (tentacular arms). These suckers are moved by muscular fascieuli which pass from the arms and are spread upon the former in a ray-like manner, and which form, moreover, with the Loligina, a peduncle.

With Tremoctopus, the suckers are cylindrical and very simple, while with the other Octopoda, their opening is closed by a membrane perforated centrally by an orifice which can be closed by a papilla that projects from the base of the sucker. (3) These organs are applied to objects at the moment when the papilla is withdrawn and removed to the base of the sucker. With the Loligina, the lateral walls of the suckers are very thin, extensible, and have upon their borders a horny and denticulated ring; in this ring the fleshy base of the sucker adjusts itself in an uncoagulate form, and upon withdrawal, produces a vacuum. With Loligospsis, and Onychoteuthis, many of the suckers on the two tentacular arms are imperfect, but, on the other hand, some of the teeth of their horny border are disproportionately developed, or the whole is changed into a strong claw. (4)

The arm-like processes about the mouth of Nautilus differ very much from the preceding. (5) They have no trace of sectorial organs, and are composed of thirty-eight prismatic filaments, which are a little flattened and transversely curled.

Each of these filaments is surrounded, at its base, by a contractile sheath into which it can be wholly withdrawn. (6) The whole fascieulus is, moreover, enveloped in a common sheath, which, upon the back, is flattened so as to resemble the foot of the Gasteropoda, and like it, probably, may serve for creeping. (5)

The portion of the skin, which extends as a kind of Natatory membrane between the arms of many Cephalopoda, contains a very loose net-work of longitudinal and transverse muscular fibres. (6)

The fins of the Loligina, have, on the contrary, large muscles composed of parallel, contiguous fascieuli which arise from the cartilages of these organs.

1 This axis is usually of a prismatic form; consequently if an arm is cut transversely the section presents a quadrilateral or rhomboidal spot in its centre; see Rang, in the Descript. de Péguyre, Hist. Nat. Pl. 1. fig. 1. w.; Owen, in the Cyclop. L. p. 528, fig. 214, c, and Férussac, loc. cit. Octopus, Pl. II. fig. 5, and Pl. XV. fig. 11, b. A similar section of the body of an Hectocotylus presents a like aspect.

2 The suckers form a single row with Eledone; a double one with the other Octopoda, and with most of the Loligina; but the rows are multiple with Sepia.

3 Although the double row of suckers on the body of Hectocotylus does not diminish towards the anterior extremity, yet, in other respects, it so closely resembles the suckers of Argonauta and Tremoctopus, that it may well be asked why this single fact was not sufficient to discover to the older observers the real nature of this pretended parasite.

4 Férussac, loc. cit. Loligospsis, Pl. IV. and Onychoteuthis, Pl. VI. VIII. &c.

5 Owen, and Valenciennes, loc. cit.

6 The internal structure of these filaments agrees pretty closely with that of the arms of other Cephalopoda. Owen, On Cephalopods with chambered shells, loc. cit. p. 8., fig. 131, Cyclop. loc. cit. p. 526, fig. 213, and Annals of Nat. Hist. XII. p. 364.

7 Owen, and Valenciennes, loc. cit.

8 The large cutaneous lobes of the median dorsal arms of Tremoctopus and Argonauta, have a similar structure. In this last genus, they are not used as ears, nor as sails, but are thrown back upon the shell to keep it in place (§ 235, note 4); they move in the water, moreover, like the other Cephalopoda, by the contractions of the mantle and the funnel (Rang, Magna. d. Zool. 1837, p. 22, Pl. LXXXXII.). It is therefore astonishing that Jeanette Power (Wiegmann's Arch. 1845, I. p. 373) should have revived the old fable that these animals raise these two large arms above the surface of the sea to be used as sails.
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With Nautilus, there are two large, particular muscles, which arise from the under surface of the cephalic cartilage, and extend, divergingly, backwards; they serve, by means of a horny plate, to fix the animal to the internal border of the shell.\(^9\)

CHAPTER IV.

NERVOUS SYSTEM.

§ 239.

The nervous system of the Cephalopoda attains a very high degree of development. Its central portion, especially, quite resembles the brain of the Vertebrata, in the extraordinary increase of its ganglionic substance, and by the presence of a cartilaginous cavity containing it, comparable to a cranium. This cavity is incomplete, it is true, but at its anterior part where the cartilaginous substance is wanting, it is closed by a tendinous cellular tissue which takes the place of a Dura mater.

The brain itself, which is far from filling the cavity of the cephalic cartilage, is enveloped by a fibrous membrane, which sends off sheaths to the nerves which leave the brain and traverse, in different places, the cephalic cartilage. The cavities remaining between the brain and this cartilage are filled with a fat-like liquid.

The primitive nerve-fibres are straight, finely granulated, and bound together into fasciculi of variable size by a very distinct neurolemma.\(^1\) The long and oval corpuscles which are often found in abundance between them, belong probably to the neurolemma.

§ 240.

The central mass of the nervous system, with the Cephalopoda, forms also an oesophageal ring, which consists of a superior and an inferior ganglionic mass connected by lateral commissures. The superior portion is small and sends some delicate nerves to the parts of the mouth. The inferior portion on the contrary, is very large, and extends along the sides of the oesophagus in order to be directly continuous with the broad commissures. The olfactory, and the two optic nerves arise from the lateral portions of this ganglion, while the auditory nerves have their origin from its inferior surface.

From its anterior border pass off four or five pairs of large nerves to the arms, and, also, others to the muscles of the head. From its posterior border arise small nerves for the funnel, and also two large trunks for the

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9 Owen, On the Nautilus, p. 17, Pl. IV, fig. 2, k., or 1st, p. 15, or Ann. d. Sc. Nat. p. 149, Pl. II. fig. 3, k., and V epic nennes, loc. cit. p. 265, Pl. XI, fig. 4, P.
1 Kolliker, Entwicklung, d. Cephalop. p. 79. According to the researches of Lebert and Robin (Müller's Arch. 1846, p. 128), the histological composition of the ganglia with the Cephalopoda is very remarkable. They have here found very large ganglionic globules, of even one-twenty-fifth of an inch in diameter, and containing, each, several nuclei.
back of the mantle. With Sepia, this inferior portion has several swellings; from the two anterior of these, which are the largest, arise the nerves of the arms; while the two lateral posterior send off the two optic nerves. With Nautilus, this same portion is divided into an anterior and a posterior transverse band, which may be compared, to a certain extent, to the semi-circle of ganglia upon the inferior surface of the oesophagus with certain Gasteropoda.

§ 241.

Among the Peripheric nerves, those of the arms and mantle should be specially mentioned. The Brachial nerves enter into the axial canals of the arms at the base of these last, and extend even to their extremity after intercommunicating, each, by a transverse anastomosis with the two neighboring nerves. In their course through this canal, they give off numerous filaments to the muscular substance of the arms and to the suckers. With the Octopoda, these nerves are composed of two parallel cords, each one of which has, alternately right and left, ganglionic enlargements.

The two Pallial nerves, which are easily seen from their size, pass, at first, between the cervical muscles, and, having reached the internal surface of the back of the mantle, terminate in two very large ganglia (Ganglion stellatum) from the external border of which pass off numerous nervous filaments, which enter, ray-like, the fleshy portion of the mantle. With those Loligina, which have fins, the pallial nerves, before terminating in the star-like ganglia, send off a large branch, which, at a short distance from its origin, is joined by another large branch from the pallial ganglion, and is then distributed to the muscles of the fin. With the long-bodied species of this family, this nerve pursues a long course by the side of the mo-
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dian line of the body until it reaches the base of the large fin-muscles, situated at the extremity of the body.\(^6\)

With *Nautilus*, numerous filaments arise from the posterior ganglionic band, and, without forming a ganglion, are distributed to the two muscles of the shell. From their origin, they may be regarded as the representatives of the pallial nerves of the other Cephalopoda.\(^6\)

Another pair of nerves corresponding to the Pneumogastric nerves of the Vertebrata, arises from the middle of the inferior cerebral mass, between the two pallial nerves, descends along the neck behind the funnel, the posterior wall of which it pierces, and thence passes under the peritoneum; here it sends several nerves to the ink-sac, and then ramifications upon the heart, the large vascular trunks, the branchial hearts, and the branchiae. Both of these nerves have ganglia, here and there, in their net-works,\(^7\) and these net-works communicate probably with the *Pleuxus splanchicus posterior*.

\(^5\) *Delle Chiage*, loc. cit. *Tav. XCV.* (25) and *CII.* (20), *Locizii*. The two parallel nerves which, with *Lolizopsis*, extend backwards along the interior dorsal surface of the mantle belong also to this class of nerves. *Graed* (loc. cit. p. 21, *Pl. II.* fig. 5, 6), has compared them to the spinal marrow of *Vertebrata*. With *Oxychateuthis*, I have also seen the two nerves of the fins running along the internal surface of the mantle, while with *Loligo*, as *Delle Chiage* has indicated in his *Tav. CL.* (30), they afterwards pass into the muscular layer of the mantle, and continue their course between it and the skin, sending off filaments to the two muscles of the fins.


7 These two nerves, analogous to the *Par vorgan*, have been observed by all the anatomists of those animals; see *Cuvier Mem.*, p. 36, *Pl. I.* fig. 4, or, *Octopus*; *Brandt*, loc. cit. *Fig. XXXII.* fig. 3, 25; *Owen*, Cyclop. loc. cit. *L.* fig. 232, c. (*Sepia*); *Van Beneden*, loc. cit. p. 18, *Pl. I.* fig. 7, b. *Pl. III.* fig. 2, k, and *Pl. IV.* r. (*Argonauta*); *Owen*, On the *Nautilus*, *Pl. VII.* fig. 1, No. 15, or, *Ibis*, *Taf. IV.* 7, fig. 1, or, *Ann. d. Sc. Nat.* *Pl. III.* fig. 4, No. 10 (*Nautilus*); and *Delle Chiage*, loc. cit. *Tav. XCV.* (25), *C. 21*, and *CII.* (20), (*Loligo, Sepia, and Octopus*).

8 For the sympathetic nervous system see *Brandt*, Uber die Mündungsorgane der *Vertebraten*, loc. cit. p. 40.


10 *Brandt*, *Owen*, and *Delle Chiage*, loc. cit. (*Sepia and Loligo*).

11 *Van Beneden*, loc. cit. *Pl. III.* fig. 1 2, and *Pl. IV.* (*Argonauta*); *Brandt*, loc. cit. *Taf. XXXII.* fig. 3 20; and *Delle Chiage*, loc. cit. *Tav. C.* (31), and *CII.* (20), (*Sepia and Loligo*).
CHAPTER V.

ORGANS OF SENSE.

§ 243.

The sense of Touch is well developed with the Cephalopoda, and is situated in the whole cutaneous envelope, in the fringed labial membranes, and, especially, in the arms. (1) *Nautilus* is particularly rich in tactile organs, which are situated on the head; and this animal has, beside the thirty-eight tentacular arms, two external, and two median, large, labial prolongations, placed about the mouth, the border of which has twelve small, curled filaments, whose internal structure quite resembles that of the arms.

The nerves of the filaments of the two external of these prolongations have an origin common with those of the arms, arising, consequently, from the front border of the anterior cerebral band. Those of the filaments of the median prolongations arise from the same band (but nearer the median line), by two common roots which, before dividing, have a flat ganglion. (2) This animal has, also, four other curled tentacles, which can be retracted in a sheath, two in front of, and two behind, the eyes. These tentacles receive a special tactile nerve, which has its origin by the side of the optic nerve. (3)

§ 244.

With the Cephalopoda, the fleshy point of the tongue is undoubtedly a Gustatory organ. It is concealed in the anterior angle of the lower jaw, and its rounding surface is covered with numerous soft villosities, which very probably serve as gustatory papillae. (4)

§ 245.

The Olfactory organs of the Cephalopoda are situated in the neighborhood of the eyes, and consist, each, of a cavity with tumid borders, or of a cutaneous fossa which has an opening, and, sometimes, at the bottom, a whitish papilla. The nerves of these organs arise from the optic ganglion of the esophageal ring, near the optic nerves. At first, they are closely united with these last, enter the orbit with them, and extend along its posterior wall, thence to the olfactory papillae, to which they are distributed in a ray-like manner. (5)

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1 Touch appears the only sense developed with *Hectocotylus*. If Cotta's figure (Ann. d. Sc. Nat. XVI. Pl. XIII. fig. 2, c. D.) is exact, *Hectocotylus argonauta* has a special tentacle-like tactile organ on the anterior extremity of the body.

2 *Oncon*, On the *Nautilus*, Pl. IV, Pl. VII. fig. 1, or 18th. 1820, Taf. III. IV., or Ann. d. Sc. Nat. XXVIII. Pl. II. fig. 1, Pl. III. fig. 1.

3 *Oncon* and *Valenciennes*, loc. cit. Pl. VIII. fig. 2, i. and Pl. IX. fig. i, i.

4 This organization appears to have eluded the observation of most naturalists. I have seen it very distinctly, not only with the * Loligina*, but also with the *Octopus*. *Oncon* (On the *Nautilus*, p. 25, Pl. VIII. fig. 7, or, 18th. p. 20, Taf. II. or, Ann. d. Sc. Nat. p. 110, Pl. IV. fig. 7, and *Cyclopia*, p. 55, fig. 226), and *Valenciennes* (loc. cit. p. 288, Pl. X. fig. 3, 4), only, have represented with *Nautilus* this part of the tongue as having all the characteristics of a gustatory organ. With *Sepia*, the soft papillae have already been figured by Savigny (Description de l'Egypte, loc. cit. Pl. I. fig. 4, 5, and in *Ferrussac*, loc. cit. *Sepia*, Pl. IV. fig. 2, 3).

5 The cavities here mentioned were for a long time regarded as the external auditory passages, and the cutaneous folds surrounding them as a Pa
dion (Ferrussac, loc. cit.). until *Kolliker* (Fra
dric's new Notes, XXVII. 1845, p. 106, and Kat
dwick, d. Cephalopoden, p. 107) discovered a special nerve, and declared, with reason, that the whole was an olfactory organ. The Cephalopoda being poor in vibratile organs, it is quite desirable to ascertain if these olfactory organs are ciliated, for they are so in fishes with which ciliated epithelium is likewise feebly developed.
§ 246. THE CEPHALOPODA.

With Nautilus, the two olfactory papillae are situated, directly beneath the eyes, in a cavity which is surmounted by a wart-like swelling. With the Octopoda, the olfactory organs are concealed, behind the eyes, in the angle of insertion of the mouth upon the occiput. With Argonauta, and Tremoctopus, they consist of two naked papillae; and with Octopus, and Eledone, of two membranous cavities.

With the Loligina, these organs are situated behind and a little below the eyes, and consist of fossae having narrow apertures; but they are easily seen from the elongated or round cutaneous swelling with which they are surrounded.

§ 246.

The Auditory organs of the Cephalopoda are situated in the lower middle portion of the cephalic cartilage, where they form two more or less large, round cavities, separated by a cartilaginous septum, and without any external communication. With the Octopoda, the internal walls of these cavities are smooth; but with the Loligina they have many tubercles or papillae, which are sometimes quite prominent. This portion of these organs may best be compared to the osseous Labyrinthus of the Vertebrata. These cavities are filled with a liquid substance, and contain, each, a small pyriform sac—membranous labyrinth—adhering to the cartilaginous labyrinth at the point where the auditory nerve enters it, and upon which this nerve is spread out. This sac contains a single, white, irregular otolite of a crystalline texture.

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2 Palaeontol. (loc. cit. p. 280, Pl. VIII. fig. 2, b, Pl. IX. fig. 1, b, x, and fig. 3) in 1841, and consequently before Kölliker, described these organs as olfactory with Nautilus. He found not only the nerve which goes to the olfactory papilla, but also an orifice at the base of this last, leading into a cavity lined with a mucous membrane which had two regular rows of folds. Owen (On the Cephalopods with chambered shells, p. 11) has regarded these papillae, which he appears to have completely overlooked in his earlier memoir, as short hollow tentacles. On the other hand, he regards as the olfactory organs a row of twenty membranous lamellae arranged longitudinally at the entrance of the mouth between the two internal lialal prolongations (On the Nautilus, p. 41, Pl. IV. 1, Pl. VII. fig. 1, g, fig. 2, or Taf. p. 54. Taf. III. IV., or Ann. d. Sc. Nat. p. 141, Pl. II. fig. 1, r, Pl. III. fig. 4, g, fig. 6); but it would appear to me that these lamellae are tactile lobules, for they receive numerous nerve-filaments from the ganglia of the nerves of the internal lialal prolongations (Owen, loc. cit.).

3 With Argonauta, and Tremoctopus, these olfactory nerves have a ganglion lying on the optic nerve (Kölliker, Entwickel. d. Cephal. p. 188); this was seen by Van Beneden (loc. cit. p. 13, Pl. I. fig. 5, 6. k), but not explained. The olfactory cavities of Octopus do not, indeed, escape the notice of Rupp (Naturwiss. Abhandl., von einer Gesellschaft, in Wurtemberg, 1828, p. 69), and of Del!e Chi!je (Descrip. &c. Tav. XVI. fig. 1, k, and Tav. XVIII. fig. 1, y), but they did not in the least suspect their nature.

4 According to Owen's account, accompanied with a figure (On the Nautilus, pl. VII. fig. 3, No. 9, or Taf. XIV. Pl. III. XXVIII. Pl. III. fig. 5, No. 9, and Cyclop. I. p. 543, fig. 252, 5), the olfactory nerves of Sepia and Loligo appear to arise from a special ganglion situated near the Glandula opticae. The entrance, with its tunic borders, of the olfactory cavities, has often been figured with the Loligina, by Ferrussac (loc. cit. Sepia, Pl. XVII. fig. 2. c. Pl. XVIII. fig. 3, b. Pl. XXVII. fig. 1, 6; Loligo, Pl. XX. fig. 7, Pl. XXIII. fig. 5, 17, Pl. XXIV. fig. 2, 11; Sepi. XXIV. Pl. VI. fig. 6, b; Sepi. Pl. III. fig. 5, 15 b.).

1 It has already been seen (§ 245) that the olfactory organs of the Loligina have been taken by some naturalists for an external ear. A very remarkable organ—a flask-shaped cavity lined with ciliated epithelium, has been seen by Kölliker (Entwickel. d. Cephal. p. 105, fig. 60-63), but, only with the embryos of Sepia and Loligo; departing from the auditory vesicles, it ran in front without opening either upon the surface of the body, or into the oesophagus, so that it could have been neither an external auditory duct, nor a Tuba Eustachi.

2 See Scarp. Anat. disquis. de audito et olito, p. 3, Tab. IV. fig. 11 (Octopus); Delle Chie![je, Descrip. &c. Tav. XIV. fig. 1, 6; and Van Beneden, loc. cit. Pl. II. fig. 3 (Argonauta).

3 See Brdndt, Mediz. Zool. p. 309, Taf. XXX. fig. 1; Wagner, Icon. Zool. Tab. XXIX. fig. 37-43; Owen, Cyclop. I. p. 544, fig. 235, and Trans. of the Zool. Soc. II. Pl. XXI. fig. 17; and Delle Chi!je, Descrip. &c. I. p. 68, Tav. XIV. fig. 12, 21 (Sepia and Loligo). This last-mentioned author has compared some of these cartilaginous prominences to the Osicula of the ear; but to me they appear to represent rather the first traces of semicircular canals, which, with the embryos of fishes, appear to consist, likewise, of simple prominences on the internal surface of the auditory vesicle.

4 These otolites are composed mostly of carbonate of lime, and very considerably in their forms. With the Octopoda, they resemble, more or less, a
§ 247.

The auditory organs of _Nautilus_ are somewhat different. They are widely separated from each other, and situated in the prolongations of the cephalic cartilage which extend in front; they consist of a very long, narrow labyrinthian cavity containing a homogeneous, thick liquid without otolites.\(^1\)

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\(^1\) The largest eyes are found with the _Loligo_; the smallest with the _Octopus_.

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The Eyes of the Cephalopoda are very highly developed and disproportionately large.\(^2\) Although resembling very much those of the Vertebrata, yet they differ from them in many respects.\(^3\) With the Octopoda, and _Loligina_, each eye has an ocular Bulb and a Capsule.

The capsule is formed by the cartilaginous orbit, and by a fibrous membrane attached to the borders of this last, and is blended externally with the cutaneous envelope. This envelope, in the form of a circular swelling, covers the eye, and, being thin and transparent, takes the place of a Cornea, — a part which, properly, does not exist with the Cephalopoda.\(^4\)

The circular swelling often has, above and below, a semilunar fold of skin containing muscular fibres, which, upon contraction, cover the convexity of the eye like an upper and under lid. The ocular bulb, contained in this capsule, is round and a little flattened in front; and, as it is not adherent to its capsule in front nor upon the sides, there is a free space, which, from the absence of a cornea, would coincide with the anterior chamber of the eye.\(^5\) In most cases, this space contains a transparent liquid, and is lined by a serous membrane covering not only the posterior surface of the anterior part of the capsule, but also the anterior surface of the bulb. It is remarkable that this same space, which contains in part the anterior chamber, communicates, externally, by a circular orifice which, with the Octopoda, is covered by the upper lid, and with the _Loligina_, is situated upon the anterior border of the cutaneous fold which takes the place of the cornea. Internally, this space can be closed by a kind of fold

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\(^3\) Krohn, Valentini, and others, admit the existence of a particular horny substance situated between the cutaneous layers of the anterior part of the ocular capsule.

\(^4\) _Trevoiran_ (Vermischte Schriften. III. p. 154) says he has observed a thin, transparent, but solid membrane, placed directly in front of the lens, and continuous with the conjunctiva (Argenteum), thus forming a completely-closed anterior chamber; but this statement requires confirmation.
or Pupil. The serous membrane just mentioned, which is spread over the ocular bulb even to the papillary border of the iris, contains a particular pigment of a silvery lustre, called the Argentea, and comparable to a Conjunctiva. (5)

With Onychoteuthis, Loligopsis, and allied genera, the anterior wall of the ocular capsule is entirely wanting, and as there is also no cornea, the crystalline lens is in direct contact with the surrounding medium (the water of the sea). In the first of these genera, the free border of the capsule has, in front, a deep fissure corresponding, perhaps, to a lachrymal canal. (6)

The Iris is formed from the argentea, which is covered on its posterior surface by a black Uvea, while its anterior surface often has chromatonic cells.

The pupil is usually of a transverse, or semilunar, rarely of a circular form, and is capable of being completely closed. (5) Under the Argentea extends a thin cartilaginous tunic — Sclerotica — which, behind, circumscribes the ocular bulb, and, in front, penetrates a certain distance into the iris. It furnishes points of insertion for the muscles of the eye, and is acriiform behind for the passage of numerous filaments of the optic nerve.

The cavity of the bulb is filled with a transparent, watery liquid which takes the place of the vitreous body, and is contained in a very thin Hyaloidea.

The Crystalline lens is spherical, and lodged in a deep depression of the vitreous body. It is of a brownish color, and its anterior surface projects through the pupil, so that the posterior chamber of the eye is only a small circular space. As with the Vertebrata, this organ is composed of numerous concentric layers, but has the remarkable peculiarity of being divisible into halves, the anterior of which is less convex than the posterior, but both are exactly joined together; the borders of these halves are quite bevelled, but are kept in place by the Ciliary body which arises from the sclerotica and lens. One part of this ciliary body embraces the borders of the lens, while the other penetrates between its halves as a thin, transparent septum. (6)

(5) Zoologists are not agreed upon the interpretation to be put on this membrane. Krohn, and Owen (loc. cit.), who regard the anterior part of this membrane as covered by a conjunctiva, consider the cavity found behind it as a large anterior chamber, filled with a Humor aqueus. Cuvier, Wharton Jones (loc. cit.), and J. Muller (in his Arch. 1856, Jahrest. p. 91), regard the capsular cavity with its serous membrane, as a closed conjunctival sac; so that the transparent convexity of the capsule is not a cornea, but a continuous closed eyelid. Moreover, as there are often found two rudimentary eyelids in the eyes of Cephalopoda (Mayer, Analekt. i. vergleich. Anat. Hist. p. 52, Taf. IV. fig. 6-11), this transparent convexity may be regarded as a third lid or a nicitating membrane adherent throughout except at the point of the opening. Many anatomists, and especially Cuvier, and Owen, have not noticed this opening of the ocular capsule. But De Blainville (Principi d'Anat. comp. 1. p. 444, and Dict. d. Sci. Nat. XLVIII. p. 292) mentions it with Loligo, Octopus, and Sepia; and Watson (Analekt. loc. cit. p. 53) has described it carefully.

In the large work of Ferussac, it is often figured under the name of Orifice irraginal; see Plate XX. fig. 7, PI. XXIII. fig. 5, a, 17.

(6) For the lens and the ciliary body, see Haschke, Comment. de pectine in oculo Avium, 1827, p. 9, fig. II, and Detta Chiogia, Osserv. anat. loc. cir. Tar. IX. fig. 1, 2, 3.

The upper papillary border, usually convex with the other Cephalopoda, is often prolonged as a Vetus or Operculum papillare. With Sepia, it is often blushed after death; see the figures of Ferussac, loc. cit. and Della Chiogia, Osserv. anat. loc. cit. Tar. V. fig. 18., and Tar. XIV. fig. 6-8. Although Mayer (Analekt. loc. cit. p. 54) declares that this lens has a capsule, yet I am undecided on this point, for the other anatomists are silent.*

These fibres however are more than twice as small as those of any of the Vertebrata I have examined.

— Ed.
The Optic nerves enter the posterior part of the orbit through a kind of 
Foramen opticum, after which they swell into a large kidney-shaped ganglion 
in which a portion of the nerve-fibres are completely interlaced with those 
from the opposite side.\(^9\) Leaving this Ganglion opticum, the nerve 
divides into numerous filaments which traverse the cribiform sclerotic, 
and then unite with the other elements of the Retina. The external layer 
of the retina is composed of these filaments; beneath it, is a pigment layer 
of a reddish-brown color, and pierced by numerous fibres given off rectangularly 
from the external layer. The internal layer is composed of 
granules, among which the fibres of the optic nerve probably terminate.\(^{10}\) The 
external layer is continuous as a thin membrane upon the ciliary body, 
and even upon the septum of lens.\(^{11}\)

The two optic ganglia are enveloped by a peculiar white substance composed 
of fat-cells, which, perhaps, serves only as a fat-cushion.\(^{12}\) The eye is moved by several straight and oblique muscles, which arise from the 
cartilaginous portion of the orbit, and are inserted, usually, upon the middle 
of the bulb.

But with Nautilus, the eyes differ in many respects from those of the 
other Cephalopoda. They are supported upon a muscular stalk and project 
from the head; while with the other Cephalopoda, excepting Loligopsis, 
they are sunken deeply in the head.\(^{13}\) From the rudimentary lower lid a 
narrow furrow passes over the anterior surface of the eye even to the small, 
circular pupil. As yet, neither cornea nor lens has here been found.\(^{14}\)

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\(^9\) For the interconnection of the nerve-fibres in the 
Ganglion opticum, — see, especially, Wharton 
Jones, and John Power, loc. cit.

\(^10\) The intimate, very complicated structure of the 
retina, has been described principally by Trec- 
trorum (loc. cit. p. 150), Wharton Jones (loc. cit.), 
and Pacini (Nuove ricerche microscop. sulla tes- 
tsituri intima della retina nell' Uomo, in Vertebra, 
eti Cefalopodi e negli Insetti. Bologna, 1845, p. 55, 
fig. 13, 14). The mysterious phenomenon, that, 
according to the older anatomists, the surface of the 
retina exposed to the light is covered with a 
 pigment-layer, rests only on an imperfect knowl- 
dge of the structure of this organ, as has been 
shown by Wharton Jones (loc. cit.), and Valen- 

\(^11\) See Krohn, and Wharton Jones, loc. cit.

\(^12\) Mayer (Annalett. loc. p. 53) regards this sub- 
stance as a semi-sudoripore gland with several excre-
tory ducts,—a kind of lacrymal gland the product 
of which is poured into the conjunctival sac; but 
Kölliker (Entwick. d. Ceph. p. 160) could find 
nothing glandular in its structure.

\(^13\) For the pedunculated eyes of Loligopsis, see 

\(^14\) The eyes of Nautilus having been studied for 
a long time upon dead specimens, it may be sus- 
pected that the above peculiarities observed by Owen, and Valenciennes, are referable to 
the want of fresh specimens. It is, at first, 
singular that Owen (On the Nautilus, p. 30, Pl. I. 
v. w., or Isis, p. 32, Taf. I, 1, fig. 1, v. w., or Ann. 
des Sc. Nat. p. 130, Pl. I. fig. 1, v. w.) speaks of a 
ridge, and Valenciennes (loc. cit. p. 289, Pl. IX. 
fig. 1, No. 3) of a furrow, running from the border 
of the lower lid to the pupil. As the cornea is 
wanting, it might almost be supposed, from examin- 
ing Valenciennes figure (PL VIII. fig. 2, P.), that 
Nautilus belonged to the Oizopodes of D'Or- 
bigny, except, that with this animal, instead of a 
complete absence of the anterior part of the semic 
capsule, there exists only a fissure, regarded by one 
of the authors in question as a ridge, and by the 
other as a furrow. The lens, not perceived by 
either Owen, or Valenciennes, escaped perhaps 
through this fissure, after having been detached 
by maceration.

As for the pigment layer, spoken of by Owen, 
as situated upon the concave surface of the retina 
of Nautilus, this problem will be explained, from 
researches upon fresh specimen in the same way, 
as with the other Cephalopods.
CHAPTER VI.

DIGESTIVE APPARATUS.

§ 248.

The mouth of the Cephalopoda\(^1\) is always surrounded by the arms, (which serve partly as prehensile organs), and by a circular fleshy lip which is fringed or denticulate on its free border. It is, moreover, covered externally by a thin cutaneous fold having a crucial opening. With the Loligina, there is, beside, a third external lip, arising as a cutaneous fold from the base of the arms; it has an heptagonal, rarely an octagonal, opening, from the angles of which project longer or shorter tentacular prolongations.\(^2\) With Nautilus, this lip is extraordinarily developed,—having four considerable prolongations provided with long tentacles.\(^3\)

Behind these lips is a round pharynx, very fleshy, and armed with two blackish-brown, horny jaws, which move against each other vertically.

Upon each of these jaws are two large lateral branches which join at an acute angle, thus forming a hooked point. The edges of these jaws being very sharp, the whole has the form of a reversed parrot's-beak, for, the edges of the lower jaw project far beyond those of the upper.\(^4\)

The pharynx is enveloped by a very complicated muscular apparatus, which arises in part from the cephalic cartilage, and moves the jaws as well as serves in producing the protraction and retraction of the pharynx.\(^5\)

Between the two branches of the lower jaw is a Tongue, which is fleshy, and resembles a long swelling adherent to the floor of the oral cavity. Upon its anterior extremity are soft gustatory papillae, and over the rest of its surface there are horny lamellae arranged in regular longitudinal rows, and golden-yellow spines which point backwards.\(^6\) Its posterior extremity is often folded over, thereby forming a kind of cavity, the opening of which is directed backwards, and continuous with a semi-canal leading into the oesophagus.

§ 249.

The intestinal canal of the Cephalopoda is wholly without ciliated epi-

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1 I have been unable to find in *Hecatonotus tumucotopos*, the orifice which Cuvier (Ann. d. Sc. Nat. loc. cit. p. 151, fig. 1, 3, 4, f., or Isis, 1822, p. 569, Taf. IX., or Frolicy's *Natu.* loc. cit. p. 8, fig. 16, 18, 19, 1) has regarded as a mouth with *Hecatonotus octopodes*; and as Kulikier (loc. cit.) says nothing about a digestive apparatus with these animals, I suspect that it is wanting here, nutrition taking place by cutaneous absorption while these bodies are in the mantles of their females.

2 See Férussac, loc. cit. the figures for Sepia, Loligo, Sepioteuthis, Onychoteuthis, and Ommastrephes.

3 See § 243.

4 Cuvier, Mém. p. 25, Pl. III. fig. 6; Savigny, *Description de l'Egypte*, loc. cit. Pl. 14 *Delle Cinque*, loc. cit. Tav. LX. (10) fig. 91, Wagner, *Icon. zoö.*, Tab. XXIX. fig. 18; and the numerous figures given by Férussac, loc. cit. According to Owen (On the Nautilus, p. 29, Pl. VIII. or Isis, p. 18, Taf. I. or Ann. d. Sc. Nat. p. 199, Pl. IV.), with Nautilus, the extremities of the jaws are covered with a bluish-white cutaneous substance, and the border of the lower jaw is denticulated; but Valenciennes (loc. cit. p. 279, Pl. XI. fig. 1, 2) has not confirmed these observations.

5 For this muscular apparatus, see Cuvier, loc. cit. Pl. III. fig. 5–6, and Anat. comp. V. p. 9 (Octopus); and Owen, loc. cit. (*Nautilus*).

The Cephalopoda. § 250.

The salivary organs of the Cephalopoda are highly developed, and consist of a superior and an inferior pair, the former of which is sometimes, but the latter very rarely, wanting. The superior pair consists of two glabrous lobes situated at the posterior extremity of the pharynx, which open by short excretory ducts behind the root of the tongue. The inferior pair lies on each side of the esophagus at the upper portion of the peritoneal sac, directly behind the cephalic cartilage. These organs, of a dull-white color, are composed of numerous inter-

1 Sepia, Loligo, Onychoteuthis, Loligoidea, &c.
2 Cuvier, Mem. Pl. IV, fig. 1, 2, b; Wagner, Icon. Zool. Tab. XXIX, fig. 14 (Octopus); Fan Beneden, loc. cit. Pl. III, fig. 3, d. (Argonauta); Peronasse, loc. cit. Octopus; Pl. III, fig. 9, 10, Argonauta, Pl. I, fig. 1, 2; and Delle Chiaje, Descr. Tav. XV, fig. 3 (Tremoctopus).
4 See the figures in Cuvier, Brandt, Ferussac, Owen, &c. The stomach of Octopus and Eledone, from its muscular walls, and its almost horny epithelium, resembles very much the gizzard of birds.
5 The cæcum, regarded as a second stomach by many zoologists, corresponds, probably, to the pyloric appendages of fishes. With Nautilus, it is a round sac, the internal surface of which has longitudinal folds, so that its cavity has a lamellated appearance (Owen, On the Nautilus, p. 25, Pl. IV, y, and Pl. VIII, figs. 8, l., or Isis, Taf. II, III, or Ann. d. Sc. Nat. Pl. II, fig. 1, y. Pl. IV, fig. 8, l.). With Loligoidea, and Sepiola, this round sac is lined internally with spiral folds (Grant, Transact. loc. cit. p. 25, Pl. II, fig. 7, g. and p. 81, Pl. XI, fig. 7, 8, c.). With Sepia, and various Octopus, it is oblong, and lined internally with transverse spiral folds supported by a kind of mesentry — see Fan Beneden, loc. cit. Pl. III. (Argonauta); Delle Chiaje, Descr. Tav. XVIII, (Tremoctopus), Sepiola, and Loligo; Cuvier, Mem. Pl. IV, fig. 1, 2, f; Wagner, loc. cit. fig. 14, f. (Octopus); Home, Lect. on Comp. Anat. Pl. LXXXIII. (Loligo vulgaris); and Ferussac, loc. cit. But, in this respect, Loligo vulgaris forms an exception; its cæcum is straight, oblong, and its thin walls are without internal pleats; see Meckel, Syst. d. vergleich. Anat. IV, p. 199, and Delle Chiaje, Descr. loc. cit. Tav. XVI, fig. 5, s.
6 The intestine is straight with Argonauta, Loligo, Sepia, Sepiola, and other Loligo; but it is flexuous with Octopus, Eledone, and Nautilus.
7 Owen, Transact. of the Zool. Soc. II. Pl. XXI, fig. 10) has found two lateral valves projecting into the oral cavity with Sepioteuthis. I have seen two similar with a Tremoctopus. Rathke (Mem. de St. Petersbourg, loc. cit. p. 160 Pl. II) has found them replaced, with Loligoida, by two transverse form prolongations.

1 Cuvier, Mem. p. 25, Pl. III, fig. 3, e. (Octopus); Ferussac, loc. cit. Octopus, Pl. XI, fig. 6, n. Pl. XIII, fig. 2, in. Owen, Cyclop. I, p. 364, fig. 218, t. (Onychoteuthis). With Nautilus, Owen found no lower, and only the traces of the upper gland (On the Nautilus, p. 25, Pl. VIII, fig. 7, g., or Isis, p. 29, Taf. II, or Ann. d. Sc. Nat. p. 114, Pl. IV, fig. 7, g.).
§ 250. THE CEPHALOPDA.

anastomosing glandular tubes, forming, sometimes, several lobes, and sometimes, a single triangular mass with a smooth exterior.

In their passage in front, the two excretory ducts converge and form, under the cesophagus, a common canal which traverses the pharynx and terminates in the mouth near the root of the tongue. The Liver is generally of a reddish-yellow color, and is rarely lobulated.

Usually, it is a compact glandular mass capsulated by a fold of the peritoneum. With the Octopoda, it is a large, smooth, ovoid gland, white with the other Cephalopoda, with a few exceptions, it is divided into two or four portions symmetrically surrounding the cesophagus. The bile, when this organ is single or double, is excreted by two ducts arising from the inferior extremity of the organ; but when this organ is quadruple, as with Nautilus, and Loligopsis, each division has a special excretory duct, and all these ducts soon unite into a common Ductus choledochus, which, after a short course, opens upon the sides of the coecum.

As a Pancreatic gland may, certainly, with reason, be regarded the pale-yellow, short, ramified glandular tubes, which, with many species, are applied to the hepatic ducts with which they communicate by many orifices.

2 For the intimate structure of these glands which appear to be wanting with Nautilus, and Loligopsis, see J. Muller, De Gland. struct. p. 51, Tab. V. fig. 9. They are lobulated with Loligo, and consist only of a small compact body with Octopoda, Eledone, Sepia, &c.; see Cuvier, Mem. Pl. III. fig. 2, 3; Wagner, Icon. zool. Tab. XXIX. fig. 34, &c.; Brandts, loc. cit. Taf. XXXII. fig. 3, 51; Ferussac, loc. cit. Octop. Pl. XII. Their surface is granulated with Sepiola, according to Delile Céph. Descr. Tav. XIXI. fig. 14, L, and Grant, Trans. Sc. Pl. XI. fig. 8, g. For the intimate structure of the liver, see Muller, De Gland. struct. p. 71 (Octopus), and Rothke, loc. cit. p. 137 (Loligopsis). For Cuvier, Wagner, and Ferussac, loc. cit.

3 With Ocychothethis Banksii, the liver is a single, very elongated mass; see Owen, in the Cyclop. I. p. 537.

4 With Nautilus, the liver is divided into four large portions, each composed of numerous lobes unbranched on each side the crop-like cesophagus; see Owen, On the Nautilus, p. 26, Pl. IV. x., or Isis, p. 22, Tab. III., or Ann. d. Sci. Nat. p. 117, Pl. II. fig. 1. z. With Loligopsis guttata, the four hepatic divisions are, according to Grant (Trans. Sc. Pl. 25, Pl. II. fig. 4, e. and 7, n.), deeply concealed in the cavity of the body; while with Loligo Echenschellii, and dubia, it is a single mass, according to Rothke (Mem. de St. Petersb. loc. cit. p. 157, 170, Pl. LI.). With Sepia, Loligo, Sepiola, &c., this organ is divided into long, smooth, externally, and extending from the neck along the dorsal median line, their length depending on that of the animal; see Brandts, loc. cit. Taf. XXXII. fig. 3, p. (Sepia), and Grant, loc. cit. Pl. XI. fig. 7, d. (Sepiola). See Cuvier, Mem. p. 39, Pl. IV. fig. 2, 4, n.; Ferussac, loc. cit. Octop. Pl. XIV. fig. 5, 6; Aragonata, Pl. P. fig. 2, 4; Owen, On the Nautilus, Pl. VIII. fig. 8, h., or Isis, Tab. II., or Ann. d. Sci. Nat. Pl. IV. fig. 8 h.; and Grant, Trans. of the Zool. Soc. I. Pl. II. fig. 7, b. Pl. XI. fig. 7, g. (Loligopsis and Sepiola).

5 This structure and arrangement of the glandular appendages of the hepatic ducts which were noticed and regarded as a pancreas by Hunter (The Cat. of the Physiol. Ser. I. p. 220, No. 775) with Sepia, is rivalled by very much of what is found in fishes, where, according to Stannius' investigations, the pyloric appendages communicate with the Ductus choledochus; see Brockmann (Stannius) De Pancreato piscinum, Diss. Kostoch. 1840. According to Delile Céph. Descr. I. p. 52, Tab. XIII. XVIII.), these bodies exist not only with Octopus, Eledone, Tremaoctopus, and Aragonata, but also with Sepia, Loligo, and Sepiola. Grant (The Eldubs. Philos. Journ. XIII. 1826, p. 197) has described them with Loligo sa-gitta, and Owen sought in vain for them with Nautilus, but found them highly developed with Sepiola, Oxychoteuthis, Sepioteuthis, and Rossia (Cyclop. I. p. 537). See also Grant, I. Trans. of the Zool. Soc. I. Pl. II. fig. 7, c., Pl. XI. fig. 7, &c. (Loligopsis and Sepiola).

6 In the species of Loligopsis examined by Rothke (loc. cit. p. 160, Pl. II.) the Ductus choledochus was dilated into a round sinus at the point where the pancreatic tubes opened into it.

* Note. These recent researches modify essentially what Stannius has said in the second volume of his work, upon the Appendices pyriformes and the Pancreas of fishes; organs not in the least identical.
CHAPTER VII.

CIRCULATORY SYSTEM.

§ 251.

The circulatory system of the Cephalopoda does not appear more highly developed than that of the other Mollusca. However, this subject is still deficient in creditable observations, and especially in those relating to the absence of completely-closed vessels.

The blood is usually colorless, or of a green-bice, or violet-bice color, and contains, proportionably, numerous round corpuscles enclosing many granules most of which are colorless, but with a few, scattered here and there, of a violet hue.

§ 252.

The Central organ of the circulation consists, with all the Cephalopoda, of a simple ventricle, situated in the centre of the cavity of the body, and surrounded with a pericardium. It is round, or oblong, and serves as an aortic heart.

With Nautilus (Tetrabranchiata), this organ receives, on each side, two branchial veins; while with the Dibranchiata there is one vein only, and the heart sends off a superior and an inferior aortic trunk. The mouth of the veins and the origin of the arteries are furnished with valves. The Ascending aorta first sends two branches to the mantle, then gives off branches to the liver, to the upper portion of the digestive canal, to the inferior salivary glands, and to the funnel. Behind the cephalic cartilage it bifurcates, forming a ring embracing the upper extremity of the oesophagus, and from which arise two arteries for the ocular bulbs, eight or ten for the arms, and many small branches for the parts of the mantle. The Descending aorta furnishes branches to the posterior part of the body; it is large in the gonyaulacan, and elongated in those of a long body. According to Kuhler (Ann. d. Sc. Nat. XVI. p. 414), Heterocyathus has also a heart communicating with arteries and veins, but he says nothing of its locality.

2 See Owen, On the Nautilus, Pl. VI. fig. 1, or Isis, Taf. IV. or Ann. d. Sc. Nat. XXVIII. Pl. III. fig. 2; Brasted, loc. cit. Taf. XXXIII. fig. 22; The Catal, of the Physiol. Sec. II. Pl. XXII. (Sepia); and Van Beneden, loc. cit. Pl. III. fig. 5 [Argopecten].

Often the two branchial arteries are widely dilated before entering the heart, and these dilatations may be regarded as auricles.

3 See Cuvier, Mem. p. 22, Pl. II. fig. 4 (Octopus); and Owen, Cyclop. I. p. 541, fig. 227 (Onyxcholothus).


Delle Chiappe, loc. cit. Tav. LXXXVIII. XC. XCI. XV. of (29, 28, 22, 24) has represented in detail the arterial system of Octopus vulgaris, Sepia officinalis, Loligo vulgaris and sagittata.

* [§ 251, note 1.] For Milne Edwards' beautiful figures see Regne anim. loc. cit. Pl. 1., 1. (Octopus).—En.
the stomach, the small intestine, the rectum, the branchiae, and the genital organs; the artery of these last, however, sometimes arises directly from the heart.

Nothing positive can now be said as to the terminal relations of these arteries; — that is, whether they are directly continuous with the venous radicles by means of a capillary system with proper walls, or whether they terminate by orifices so that the blood is effused immediately into the parenchyma of the body. 6

The Venous system begins in the different parts of the body by numerous small vessels, of which we are still ignorant whether they are continuous with the terminal arterioles, or whether they commence by themselves with proper orifices. Their radicles unite and form longer branches which finally open into a large Sinus. One of these sinuses, which is of a circular form, surrounds the upper extremity of the oesophagus, and receives the veins coming from the eyes, the arms, 7 and the parts of the mouth. From this sinus arises another, of an oblong form, which, since it extends into the cavity of the body and receives the different veins from the visceræ, may be called a Vena cava superior. In the centre of the body it divides into two large vanae cavae which extend on each side to the base of the branchiae 8 and terminate in the two so-called branchial hearts. 9

These two veins receive, also, two trunks, which bring the blood from the mantle and are often dilated into two large sinuses. 10

The distinct, but often very thin walls of the venous sinuses, are sometimes so intimately blended with the adjacent organs, that these sinuses may be easily taken for wall-less lacunæ. 11

6 Milne Edwards and Valenciennes (loc. cit.) throw no light on these questions. It is moreover singular that in the numerous and often very detailed figures of Delile Chigio of the vascular system of Cephalopoda, he has nowhere represented in the least a capillary net-work between the arterioles and veins, while Köllicker (Entwick. der Cephal. p. 81), declares that he has seen numerous capillary vessels in the embryos of Sepia.

7 All the arms of the Cephalopoda have two venous trunks. Lebert and Robin (Maller's Arch. 1846, p. 130) have observed, in the venous system Sepia officinalis, a valve preventing the reflux of the blood towards the head.

8 With Nautilus, this sinus is divided into four vena cavae (Owen, loc. cit.). 9

The so-called Branchial hearts of the dibranched Cephalopoda have no muscular fibres, but have a very glandular aspect, and are in close relation with the urinary organs; see below, § 253.

10 Delile Chigio, loc. cit. Tav. LXXVII. LXXXIX. XCI. XCVIII. (17, 27, 21, 23), has also figured with many details the venous system of Octopus, Sepia, and Loligo.

11 It is, therefore, difficult to decide if the large cavities which Milne Edwards (Ann. d. Sc. Nat. III. loc. cit. Pt. XIII—XVI.) has injected, were dilated veins or simple lacunæ. In this last case, the venous system would communicate directly with the cavity of the body, and there are many circumstances in favor of this view. It is, therefore, to be regretted that Milne Edwards did not, in his researches, pay more attention to the aquiferous system which is spread through the whole body of the Cephalopoda, and thus, for the present at least, prevent the objections, that these aqueous reservoirs should be confounded with the venous sinuses. The lymphatic reservoirs which, according to ERED (Wiegmann's Arch. 1845, I. p. 163) surround, and can be injected by means of the arteries, are also, perhaps, venous sinuses. An observation of Owen (On the Nautilus, p. 27, Pl. VI. fig. 1, No. 1, or Isis, p. 24, Tat. IV., or Ann. d. Sc. Nat. p. 121, Pl. III. fig. 2, No. 1), and of Valenciennes (loc. cit. p. 257), that the large superior vena cava communicates with the abdominal cavity by numerous orifices, is of much importance. For, in this way, this vein must be regarded as a large blood-reservoir, conducting, very probably, the nutritive fluid, after its transudation through the intestinal canal, into the general blood current.

The pericardium of the Cephalopoda sustains, perhaps, analogous relations to the blood-system, for, with Nautilus, it is said to communicate with the abdominal cavity, and with the principal vena cava, with the other Cephalopoda; see the concluding paragraph of note 1, § 251.
CHAPTER VIII.

RESPIRATORY ORGANS.

§ 253.

All the Cephalopoda respire by means of Branchiae. These are situated in the cavity of the mantle, separated from the other viscera, and outside of the peritoneum. Hectocotylus forms the only exception in this respect,—its branchiae being free, and placed along the sides of the anterior half of the body under the form of numerous oblong, thin, thickly-set lamellae. Nautilus has, on each side, two branchiae, while the other Cephalopoda have only one.

These organs have a more or less oblong, pyramidal form, and are attached, at one of their borders, to the external surface of the mantle by a thin cutaneous fold,—leaving their extremity to extend freely in front. The adherent edge is bordered by the trunk of the branchial artery, and by a large glandular band, while the free border is occupied, from its base to the top, by the principal branchial vein. With Nautilus, and the Loligina, there are, between these vessels, numerous, triangular, branchial lamellae lying upon each other, and plicated upon both surfaces. But with the Octopoda, these lamellae are replaced by arches, which, on each side, pass from one vascular trunk to another, and have, upon their convex edge, a multi-plexicated membranous band. The branchial vessels extend from the branchial artery to the branchial vein through the lamellae and the branchial arches; and in this passage, the venous is changed to arterial blood.

As there is no ciliated epithelium on the surface of the branchiae, the water is renewed exclusively by the rhythmical respiratory movements. It enters, from both sides of the funnel, into the interior of the mantle when its borders are open, and is ejected through the funnel by the contractions of the mantle when its borders are closed.

1 I have found such with Hectocotylus tremoctopodis according to Kühlcr (loc. cit.) that of Argonauta also has branchiae.
2 This glandular body has been regarded by Cuver (Mem. p. 20, Pl. II. fig. 3, Pl. III. fig. 1, A.) and other zoönomists as a muscular stripe; while Moger (Annlchern., etc., p. 36, Taf. V. fig. 1, No. 14), from its cellulo-vascular texture, has taken it for a spleen. I have been unable to find in it any muscular fibres, but only numerous cells, and I am of the opinion that this enigmatical organ holds some special relations with the venous system.
3 See Queen, On the Nautilus, p. 30, Pl. VI. fig. 1, 2, or Isis, p. 20, Taf. IV., or Ann. d. Sc. Nat. p. 124, Pl. III. fig. 2, 3, and Valencennes, loc. cit. p. 281, Pl. IX. x.; The Catalog. of the Physical. Petr. II. Pl. XXI, XXII. (sepia); Trevisanu, Beobacht. ans. d. Zool. u. Physiol. p. 37, Taf. VIII. fig. 52-54; Grant, Transact. of the Zool. Soc. I. Pl. II. XI. (Loligopias and Sepiolas); Cuver, Mem. p. 20, Pl. II. III.; Delé Chjio, Descr. Tav. XIX. fig. 1-5 (Octopus); Pérussac, loc. cit.
4 The number of the branchial lamellae and arches varies very much. With Nautilus, each branchia is composed of a double row of forty-eight lamellae; the long-lobed Loligina have a double row also, composed of sixty to ninety lamellae. With Sepia, there are thirty pairs; and with the Octopoda, the number of branchial arches is still less; there are only fifteen pairs with Argonauta, and twelve alone with Octopus, and Eledone.
5 For the distribution of the blood-vessels in the branchiae of Sepia, see Tilius, De Respirat. Sepiæ officinalis, Tab. I. II.
6 That, with the Cephalopoda, which are in general so poor in cells, there should be no ciliated epithelium on the branchiae, is so remarkable a fact, that I have had it confirmed from fresh specimens by my friend H. Koch at Trieste, although Sharpey (Cyclop. 1. p. 619) had already spoken of it.
7 For these respiratory movements, see Graem enhorst, Tergastina, p. 1, and Wagner, in the Isis, 1833, p. 159.
§ 254.

The existence of an Aquiferous system with the Cephalopoda cannot be doubted.1 It occupies the entire trunk of these animals, and terminates by two orifices between which lies the excretory duct of the ink-sac, and which are often situated upon a small tubular eminence of the peritenon. Each of these orifices leads into a spacious, thin-walled cavity (lateral cell),2 situated near the pericardium. It contains the two venae cavae with their appendages, and communicates, by orifices and canals, with other aquiferous cells surrounding the various viscera, — such as the stomach and the caecum, as well as with the two so-called branchial hearts. These cells send a canal to the special genital glands.3

With Nautilus, there are, on each side, in the abdominal peritenon, three orifices, through which the water of the cavity of the mantle enters into the lateral cavities.4 There is another system of aquiferous canals under the skin of the head and neck. It consists of several large reservoirs which extend somewhat deeply between the organs of this portion of the body. These reservoirs communicate externally by orifices situated upon different points of the head.5

CHAPTER IX.

ORGANS OF SECRETION.

I. Urinary Organs.

§ 255.

The Urinary organs of the Cephalopoda, which have hitherto been much doubted, are particular appendages of the Venae cavae. With all the species having two branchiae, the two Venae cavae, formed by the division of the great median sinus, and which extend obliquely through the two lat-

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1 For this aquiferous system, see D'Orbigny, in Ferussac, loc. cit. Introduct. p. 20, Ouvr., aquiferes, and Delle ChiJe, Descriz. 1. p. 51. Apparato-aquifero e idro-pneumatico. Both of these naturalists have included in this system the bacular openings and the space circumscribed by the ocular capsules.

2 See Swammerdam, loc. cit. p. 354, Taf. II. fig. 1, q. q, and Taf. III. fig. 10, g. g; Brandt, Medizin. xxod. II. p. 308, Taf. XXII. fig. 1, 24, l. i (Sepia); D'Orbigny, loc. cit. p. 15, Taf. I. fig. 1 r. r, and Mayer, Anouletk. &c. p. 51, Taf. V. fig. 1 t. u. (Octopus); Switzcngy, loc. cit. Pl. I. fig. 12, 3d. g. g (Octopus and Sepia), and Ferussac, loc. cit. (Octopus), Pl. XII. fig. 1. Pl. XIII. fig. 2. Pl. XIV. fig. 1, f. fig. r. See also Krohna, in Muller's Archiv. 1839, p. 353.

3 Delle ChiJe, Descriz. Tav. XV. fig. 1. q. (Tremoctopus).


5 With Tremoctopus violaceus, there are four very distinct Foramina aquifera. Two of these are situated at the superior part of the head behind the base of the superior arms, and the other two on the sides of the funnel (Delie ChiJe, loc. cit. Tav. LXXI. (11) fig. 10, p. Ferussac, loc. cit. p. 92. Octopus, Pl. XVII. XIX. fig. 1). With Octopus tuberculatus, there are only these last two openings (Delie ChiJe, loc. cit. Tav. LII. (5) fig. 1, d. d.; Wagner, in Heisinger's Zeitsch. f. d. organ. Physiol. 11. p. 227, Taf. XII. fig. 1, and Ferussac, loc. cit. p. 88, Octopus, Pl. VI. fig. 2).

It is the same also with Ommastrephes todorus (Ferussac loc. cit. Ommastrephes, Pl. II. fig. 3, 10). With Octopus indicus, there are eight small aquiferous orifices between the arms near the mouth (Ferussac, loc. cit. p. 29, Octopus, Pl. XXVI. fig. 1). According to D'Orbigny, there are only six, in the same situation with Sepia, Loligo, Oxypho-testes, &c.
eral aquiferous cells to the base of the branchiae, have, exteriorly, variously ramified, glandular tufts which project into the aquiferous cells.¹ Sometimes similar appendages are found also upon the principal veins which open, in these cells, into the venae cavae.² With Nautilus, which has on each side in the peritoneum four venae cavae, each of these last extends between two cells each of which receives a part of the glandular appendages with which it is provided.³

These organs, for a long time known as the Spongy bodies, can now be regarded positively as kidneys; for, by chemical analysis, it has been proved that they secrete urea acid.⁴ Careful examination of them has shown that their parenchyma consists of a tissue of contractile fibres,⁵ among which are spread branches coming from the venae cavae.

This parenchyma is surrounded by a structureless membrane, covered with several layers of nucleated granular cells. The urine is secreted from the external surface of this cellular layer; it is of a dirty-yellow color, and escapes immediately into the peritoneal cavities, and thence is discharged externally through their orifices, which may, therefore, be taken for urethral canals. These spongy appendages of the veins ought, therefore, to be regarded as everted glandular follicles, the secreting cells being situated externally and the blood-vessels within.⁶ Not unfrequently, the reddish crystals formed in the urine, completely inure these glands, giving them their peculiar color.⁷

The so-called Branchial hearts of the Dibranchiata contain no trace of muscular fibres, and appear to be in some way connected with the urinary organs. They are round, hollow, thick-walled, and lie upon the course of the venae cavae between the last renal masses of the branchiae, so that the blood of these veins passes into their cavities and bathes their spongy walls.⁸ Their color is violet with the Octopoda, and pale-yellow with the

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¹ *Cuvier, Mem.*, p. 18, Pl. II. fig. 1, 3, Pl. III. fig. 1, x; x; *Wagner*, Icon. zoöl. Tab. XXIX. fig. 14, q. q. 16; *Delle Cittaje*, loc. cit. *Tav.* XXXVII. XVI./XCII. *XCIII.* (17, 21, 23, 19); *Carus, Erläuterungstafeln*, Ht. VI. Tab. II. fig. 15, 17; *Mayer, Annalen*, Taf. V. fig. 1, s. s. (Octopus); *Grant*, Transact. of the Zool. Soc. I. Pl. II. fig. 8, a. b. Pl. XI. fig. 9, b. b. (Loligoidea and Sepiolida); *Van Beneden*, loc. cit. Pl. III. fig. 5, f. f. (Argonauta).

² *Krohn*, in *Marter's Arch.*, 1859, p. 555, and *Brandt*, loc. cit. *Taf.* XXXII. fig. 2. x.

³ *Owen*, On the *Nautilus*, p. 51, Pl. V. No. 6, Pl. VI. fig. 1, No. 6, or *Ibis* p. 26, *Taf.* III. IV., or Ann. d. Sc. Nat. p. 126, Pl. III. fig. 1, 2; and *Valeviciennes*, loc. cit. p. 286, Pl. V. fig. 2, 4.

⁴ These appendages have been successively regarded as absorbent vessels, a rudimental portal system, a spleen, accessory branchiae, blood- reservoirs, genital organs, &c. *Mayer* (Annal. &c. loc. cit. p. 54) was the first to regard them as urinary organs, but this view was not commonly received. The two peritoneal cavities containing these organs, were also taken by him for urinary bladders, and their orifices as urethrae. The same function has also been attributed to these organs by *Savi* (Atti della terza riunione degli scientifici temuti nel Firenze, 1841, p. 296, or *Ibis*, 1843, p. 417).

⁵ At my request, *E. Harless*, while at Trieste, subjected these organs to a chemical analysis, and, as he obtained from their contents purpurea of Ammonia, there can be no doubt that they are really kidneys.

⁶ The contractility observed in these appendages is due, without doubt, to this fibrous tissue (*Krohn*, in *Forsey's* new *Ibis*, XI. 1829, p. 214, and *Erdl*, in *Wiegmann's Arch.*, 1843, p. 162).

⁷ I am indebted for this remarkable histological fact to a recent communication from *Harless*.

⁸ I have often found in the kidneys of the *Septa officinale* groups of rhomboidal crystals of a crimson red color. *Krohn* (Forsey's new *Ibis*, XI. p. 210) has found them constantly with *Septa*, but has sought in vain for them with *Octopus*, and *Loligo vulgaris*.

⁹ The so-called branchial hearts, which are wanting with *Nautilus*, and in which, it seems, pour the blood into the branchiae with the other Cephalopoda, are surrounded by a smooth peritoneal envelope, and have, internally, a cavernous aspect; see *Cuvier, Mem.*, Pl. II. fig. 5, No. 9 (Octopus); *Carus, Erläuterungstafeln*, Ht. VI. 1845, Tab. II. fig. 18, *Septa*. With the Loligina, a constriction sit-
Loligina. Their walls are composed of a dense web of cells, which, with the Octopoda, contain round, violet nuclei, of a crystalline texture and resembling entirely those found in the renal cells of the Gasteropoda.

II. Organs of Special Secretions.

§ 256.

The Ink-sac is an organ generally common with the Cephalopoda. It is usually pyriform, situated upon the median line of the abdomen, and often enveloped with a peritoneal layer of silvery lustre. Its apex points forwards and upwards, towards the funnel. The walls of its generally small cavity are cavernous, and secrete the well-known black pigment, which, through contractions, passes into the funnel, and is then expelled, mixed with the water of the sea, which is passing out of the body. The excretory duct of this sac runs along the rectum, and terminates just behind the anus, or opens into the rectum.

As an organ, also, of special secretion, ought to be regarded the completely-closed chambers found in the shell of the Nautilina; for it is said that their walls, like those of the natatory bladder of fishes, secrete a gas.

CHAPTER X.

Organs of Generation.

§ 257.

The Genital organs of the Cephalopoda are always distributed upon two individuals, and present very remarkable peculiarities.
The Eggs, at their escape from the ovary, are oval, and have a yellow, or rose-colored vitellus, containing a germinative vesicle and dot.

The vitelline membrane has transverse and longitudinal folds on its internal surface, which extend into the vitellus,—giving the eggs a reticulated aspect.\(^1\)

The Spermatid particles are very active, of a cercarian, or a simply capillary form, and, as a whole, give the sperm a white color. Those of a cercarian form are proper to the Loligina, and consist of a cylindrical body to which is rather abruptly attached a small and pretty long tail.\(^2\) Those of a capillary form are found with the Octopoda, not only with the males of Octopus and Eledone, but also with Hectocotylus.\(^3\)

\[\text{\S} \ 258.\]

The Ovary, always simple, is situated, at the base of the sac of the mantle, in a solid envelope (ovarian capsule) of a round or oblong form, and derived from the peritoneum. At its circumscribed point the proper ovary commences as a multi-lobulated body filling its cavity.\(^4\) The eggs, which are developed in the parenchyma of these lobes, appear first as round prominences; they gradually increase, and, finally, are attached to the ovary only by a small peduncle. At this epoch the ovary furnishes them with a thin envelope (egg-capsule), through which, in the mature eggs, the reticulated folds of the vitelline membrane can be seen.\(^5\) When the eggs are fully matured, their capsules burst, and they fall into the ovarian capsule, after which, their proper capsules fade and finally disappear.\(^6\) From the ovarian capsule they pass into the oviduct through an infundibuliform opening; but, beside this opening, some Octopoda have also two others belonging to an aquiferous canal, and which, perhaps, play an important part in the fecundation of the eggs.\(^7\) The oviduct is simple, or double, and extends directly in front opening at the base of the funnel near the rectum. With Argo-

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\(^1\) See Kolliker, Entwicklungsgesch. &c. p. 1, \(9, 14.\)
\(^2\) These longitudinal and transverse folds have been observed in the eggs of Sepia and Sepio-\(\text{ta}^3\); the longitudinal only are found in those of Argonauta, Tremoctopus, Octopus, Eledone, &c.
\(^3\) See my Beiträge z. Naturgeschichte d. wir-
\(^4\) Gossenich, in Behng. \(13^2, \text{Hft. II. p. 54, Taf. II. fig. 17 (Loligo); Milne Edwards, Ann. d. Sc. Nat. XVIII. 1812, p. 337, Pl. XII. fig. 6, Pl. XIII. fig. 7 (Loligo and Sepia), and Peters, in Muller's Arch. 1842, p. 844, Taf. XVI. fig. 14 (Sepiola).\)
\(^5\) It is easy to observe the development of the spermatic particles in the testicles. According to my observations, the daughter-cells in the mother-cells, are developed into as many spermatic particles the tails of which rupture one of the thin sides of the mother-cell.
\(^6\) Milne Edwards (loc. cit. Pl. XIII. fig. 11, Pl. XIV. fig. 6), has erroneously figured the spermatic particles of Octopus and Eledone with a very large body; for it is only a small button-like en-
\(^7\) largement; see Valenciennes, Repert. 1837, p. 149, and Philippi, in Muller's Arch. 1839, p. 366, Taf. XV. fig. 11. This list has represented the tail of that of Eledone too short.
\(^8\) I have found the spermatic particles of Hecto-
cotylus tremoctopus to be exactly like those of Eledone.

1 Cuvier, Mém. p. 31. Pl. IV. fig. 6, a. b., Van Beneden, loc. cit. Pl. V. fig. 2, a l. Delle Chiave, Descriz. Tav. XIV.-XVI., and Grant, Trans. of the Zool. Soc. i. Pl. II. fig. 9 (Octopus, Argonauta, Eledone, Loligo, and Loligopsis).
2 Delle Chiave, Descriz. Tav. XV. fig. 15, and Kolliker, Entwick. &c. Taf. I. fig. 9 (Sepia); Carus, Erlauterungstaf. Hft. V. Taf. II. fig. 9 (Eledone).
3 With Sepia, the destruction produces a rent with irregular borders (Kolliker, loc. cit. p. 15); with Rossia, and Sepia, a simple round opening, which, with Nautilus, according to a figure of Owen's, has erenulate borders, and, according to Delle Chiave, is regularly deciliated with Eled-
\(\text{one}^3, \text{see Grant, Transact. loc. cit. i. p. 54, Pl. XI. fig. 12, and Owen, Hft. II. Pl. XXI. fig. 18, also, On the Nautilus, p. 42. Pl. VIII. fig. 9, c. c., or Isis, p. 55, Taf. III. or Ann. d. Sc. Nat. p. 142, Pl. IV. fig. 9, c. c, and Delle Chiave, loc. cit. Tav. LV. (5) fig. 15.
4 These two aquiferous canals form a communica-
tion between the ovarian capsules and the aquifer-
ous cells surrounding the branchial hearts (§ 280). They are found with Octopus, Eledone, and Trem-
\(\text{octopus}^3; \text{see Krabbe, to Muller's Arch. 1839, p. 357; Kolliker, Entwick. &c. p. 11, and Delle Chiave, Descriz. Tav. XV. fig. 1, q. (Tremocto-
\[\text{pus}).\]
§ 258. THE CEPHALOPODA.

wide apart, in the region of the base of the branchiae.\(^5\) When there is only a single oviduct, it terminates always on the left side.\(^6\) With most of the Octopoda, the oviducts, at near the middle of their course, traverse a round glandular body, the internal surface of which is longitudinally plicated; from this point to their extremity, they are covered with analogous glandular folds.\(^5\) This glandular body is absent with the Loligo, but the walls of their oviduct become thick and glandular before terminating.\(^5\) It is very probable that this glandular apparatus furnishes the materials of the various envelopes of the eggs after their escape from the ovary.

There is another peculiar glandular apparatus (Nidamental glands) having no direct connection with the genital organs, which consists of two hollow, pyriform, whitish bodies, situated above the ink-sac of the female Loligina. These bodies have a lamellated structure and their obtuse extremity extends forwards; they open near the genital orifice.\(^5\) Sometimes, directly in front of these glands, there is another gland, simple or double (accessory nidamental gland), of a reddish color, lobulated posteriorly, composed of coeca, but apparently without any excretory duct.\(^6\) This whole glandular apparatus secretes, perhaps, a substance with the eggs are coated as they pass from the oviduct, and which serves to glue them to foreign bodies.

The deposited eggs (spawn) are always surrounded with envelopes and prolongations of various forms, by which they are bound together and attached to submarine bodies. Thus, those of Sepia are enclosed, each, in a black, oval capsule, composed of several horny layers, which is prolonged at one of its extremities into a short, clert peduncle, by which the eggs are attached, singly or in groups, to marine plants;\(^6\) but those of the Loligina are united by a colorless gelatious substance into a chaplet, and are enclosed, moreover, each, in a special capsule one of the extremities of which has a small peduncle; thus arranged, they form large masses floating free

5 With Octopus, Eledone, Tremoctopus, and Loligo saltator, there are two oviducts; see Owen, Mem. Pl. I. fig. 1, r.; Mayer, Analekten, Tab. V. fig. 1, l. l. f. 13; Ferussac, loc. cit. Octopus, Pl. XV. fig. 2, I. 1.; Cuvier, Erklärungstat. Hft. V. Tab. II. fig. 7, h. h.; Wagner, Icon. Zool. Tab. XXIX. fig. 20, m. m.; Owen, Trans. of the Zool. Soc. II. p. 121, and Cyclop. I. p. 555. With Aragonula, these two oviducts are very long and flagellate; see Delle Chiuse, Descriz. Tab. XIV. fig. 1, z. n.; and Van Beneden, loc. cit. Pl. V. fig. 1, 2; Ferussac, loc. cit. Aragonula, Pl. I. \(^4\) fig. 2, s.s.\(^6\)

6 Such is the case with Nautilus pompilius (Owen, loc. cit.), Loligo vulgaris (Cuvier, Erklärungstat. Hft. V. Tab. II. fig. 10, m. l.), Sepia officinalis, Septipenthus, Rossia, &c. According to Raktkhe (Mem. d. St. Petersbourg, loc. cit. p. 101, Pl. II. fig. 10, r. p. q.) the simple oviduct of Loligopsis passes directly to the posterior part of the body and terminates at the ventral median line between the two fins.

It is, however, desirable that this remarkable exception to the general rule should be confirmed by other anatomists, for Grant (loc. cit.) is wholly silent upon the e-areas of the oviduct in the females of Loligopsis which he examined.

7 With Octopus, Eledone, and Tremoctopus, each oviduct has such a glandular enlargement, but it is entirely wanting with Aragonula; see Cuvier, Mem. p. 32; Pl. IV. fig. 6, g.; Ferussac, loc. cit. Octopus, Pl. XV. fig. 9, 10.; Mayer, Analekten, Tab. V. fig. 1, p. h. (Octopus); Delle Chiuse, loc. cit. Pl. XXIX. fig. 1, n.; Cuvier, Pl. II. fig. 6, and Wagner, Icon. Zool. Tab. XXIX. fig. 20, n. n. (Tremoctopus and Eledone).

8 This is so with Loligo, Sepia, Septipenthus, Septipenthus, &c.; see Owen, Trans. II. p. 121, Pl. XXI. fig. 18, o. (Rossia). With Nautilus, the very short oviduct has glandular walls in its whole extent (Owen, loc. cit.).

9 See Suwanmerdan, Bibl. d. Natur. p. 354, Tab. XIII. fig. 10, g. g.; Brandt, loc. cit. p. 313, Tab. XXXII. fig. 23, k. l., fig. 25-21 (Sepia); Delle Chiuse, Mem. IV. p. 102, and Descrier, I. p. 37, Corpis adiportis, Tab. LVIII. (12), fig. 10, a., l., c.; Peters, in Muller's Archiv. 1842, p. 354, Tab. XVI. fig. 6, \(\text{f. f. (Sepia;)}\) Owen, Trans. of the Zool. Soc. II. Pl. XI. fig. 18, g. g. (Rossia).

10 With Sepia, and Sepiola, this gland is single, and divided by deep fissures into three lobes (the figures cited in the preceding note, and Owen, Trans. &c., loc. cit. Pl. XII. fig. 19, 20) with Loligo, and Rossia, it is double, and each is divided into two lobes (Owen, Ibid. Pl. XXII. fig. 18, h. h.).

in the sea. With those of *Argonauta* and *Tremoctopus*, the envelope is composed of a solid, homogeneous, colorless substance, and at their pointed extremity there is a small filament; these filaments being entangled together, the eggs form large botryoidal masses. *Argonauta* attaches these bunches to the convex portion of its shell; but *Tremoctopus*, with which these masses are in chalpels, forms them into a staff-like structure, by means of a tissue of leathery consistence, secreted for this purpose. With the other Cephalopoda, the eggs are arranged in tubes or in fillets.

§ 259.

The simple, round, or oblong, whitish Testicle, is situated, in most species, at the bottom of the cavity of the mantle. It is surrounded by a capsule derived from the peritoneum but adherent to it only at one point. It is composed of numerous ramified cylinders, converging from the periphery towards the centre, which is occupied by a narrow irregular cavity.

The sperm is formed in the intervals of the cylinders and thence passes into the deferent canal, which, at its passage from the testicular capsule, is narrow and very flexuous, but suddenly dilates at its upper extremity, — where its walls are thick and glandular, and have a longitudinal fold on their internal surface.

This glandular portion of the *Vas deferens* receives the orifice of an equally flexuous caecum, which is probably an organ of secretion; and terminates, finally, in a large sac with muscular but thin walls which are plicated longitudinally. This sac, known as the *Bursa Needhamii*, is followed by a fleshy tube (*Ductus ejaculatorius*), which extends directly in front and projects, as a short penis, into the cavity of the mantle near the rectum.

With the Loligina, and with *Octopus*, and *Eledone*, the sperm is not freely evacuated, but is enclosed in very complicated organs (*Spermatophores*), which, at the epoch of procreation, accumulate in abundance in the *Bursa Needhamii*, and are large enough to be seen with the naked eye. They are always cylindrical and consist of a homogeneous, colorless, solid tube, round at the anterior extremity, but at the posterior end, somewhat constricted and then dilated into a kind of sphere. Each of these Spermatophores contains two kinds of organs: a very thin sac filled with spermat particles, and an apparatus to project these particles outwards.

The Sperm-sac always contains fully-developed spermat particles bundled together: it nearly entirely fills the cavity of the tube, through

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12 These chalpels are long with Loligo vulgaris, and short with *Sepia officinalis;* see Burdach, *De quinque animal. marinar. p. 155, Tab. XII.; Ferrussiac, loc. cit. Loligo, Pl. X. fig. 1, 15, and Kuhlker, loc. cit. p. 14.


14 This body has a peculiar structure; and undoubtedly, is made by the animal itself. It is composed of numerous, superposed, very distinct layers of a granular, probably conglutated substance; — forming a kind of staff or baton by which the eggs are bound together in groups; for, according to Kuhlker (loc. cit. p. 14), it (*Tremoctopus*) carries the entire mass attached to the suckers of one of its arms.


1 For the male genital organs of *Octopus*, see Cuvier, *Mém. loc. cit. p. 32, Pl. IV. fig. 5; he regards the upper glandular portion of the deferent canal as a *Fistula seminalis*, and the caecum appended to it as a *Prastata*. See, also, Delle Chiagio, *Descriz. Zool. XVI. fig. 2. Spermis* and Loligo; Wagner, *Icon. zoöd. Tab. XXIX. fig. 22 (Octopus); *Peters, in Müller's Arch. 1842, p. 352, Tab. XVI. fig. 3, 5 (Sepia); and especially the beautiful figure of those of *Sepia* by Milne Edwards, in the Ann. d. Sc. Nat. XVIII. 1842, p. 344, Pl. XV.
which it is seen of a milk-white color. Its posterior extremity is attached, by a short, small ligament, to a kind of piston which forms the anterior portion of the projectile apparatus.

This piston is a solid, cylindrical body, continuous behind with a spiral ligament which is contained in a thin sheath extending to the posterior extremity of the tube, in a fold of which it terminates.\(^5\)

The Spermatophores are evidently formed in the upper glandular portion of the deferent canal, where droplets of sperm are often seen arranged in rows, and, at first, appear surrounded by simple, colorless envelopes; these, as they advance in the \textit{Vas deferens}, gradually resemble more and more the perfect Spermatophores.

Those found in the \textit{Bursa Needhamii} are always regularly arranged, and sometimes form, lengthwise, several superposed layers. Their anterior extremities always point forwards, and not unfrequently their posterior ends are bound together by long, flattened, interlaced filaments. These Spermatophores are in the highest degree hygroscopic: they absorb liquids very quickly, and then their posterior extremity bursts, allowing the escape of the compressed spiral ligament together with its sheath, and the piston, which draws with it the sperm-sac to which it is attached.\(^5\)

The projection of the seminal sac occurs, most probably, at the moment when, during coition, the Spermatophores pass from the penis of the male into the sac of the mouth of the female. A true intromission of the penis into the female genital opening appears impossible with these animals, so that coition consists only in a simple juxtaposition of the genital organs.\(^6\)

The fertilization of the eggs should occur very early — while the eggs are

\(^2\) Neatham (An account of some new Microscopical Discoveries, London, 1745, or Nouv. découv. faites avec le Microse. Leyde, 1747, Pl. III. IV.), was the first who described accurately the Spermatophores of \textit{Loligo vulgaris}. With those of the Loligina, the posterior extremity is enlarged, with one or two constrictions, and contains the spiral ligament with its sheath; the piston also, from its deep-brown color, is easily seen; see Kroha, in \textit{Forriepe's} neue Notiz. XII. 1839, p. 17, fig. 29 (Sepiola); Needham, in \textit{Spermatophores of Loligo} (De Sc. XVIII. 1842, p. 355, Pl. XII. fig. 1-5, XIII. fig. 1-6 (\textit{Loligo and Sepia}); Peters, in Muller's Arch. 1842, p. 354, Taf. XVI. fig. 11 (Sepiola). With those of \textit{Octopus}, and \textit{Eledone}, the posterior enlargement is very slight, and often, at this point, the envelope is entirely involuted; the seminal sac, moreover, is remarkable from its spiral form; see Milne Edwards, loc. cit. p. 338, Pl. XIII. figs. 8-10, XIV. fig. 1-6 (Octopus and Eledone); Philippi, in Muller's Arch. 1839, p. 201, Taf. XV. fig. 1-6 (Eledone); this last author has erroneously taken the spiral turns of the ligament for hooks pointing backwards.

\(^3\) Reitl (De Animalibus vivis quae in corporibus aspens vivorum reperientur, Lugd. Batav. 1729, p. 322, Tab. II. fig. 2), was the first who saw these Spermatophores; but he took them for worms. \textit{Sowerwardianum}, on the other hand (Rib. d. Natur, p. 334, Taf. III. fig. 5, 7), and especially \textit{Neatham} (loc. cit.), had a correct idea of their nature, for they regarded the white substance they contained as sperm, and the Spermatophores themselves as a kind of cases or capsules. But this did not prevent the later anatomists from regarding them as parasites. Thus Delle Chiaje described those of \textit{Octopus} and \textit{Sepia} under the names of \textit{Monostoma octopodis}, and \textit{Scoleus dibothrius} (Mem. IV. p. 53, Tav. IV. figs. 8, 14, 9, 9). Even lyterry, this naturalist has not relinquished this opinion, for he

\(^4\) Aristotle (Hist. Animal, lib. V. cap. 5) had already declared that the Cephalopoda copulate by a kind of embrace. From the observations of Le- bert and Robin (loc. cit. p. 175, and Ann. d. Sc. Nat. IV. 1845, p. 95, Pl. IX. fig. 5, 6), it would appear that the males do not deposit the spermatic particles further in than the cavity of the mantle of the females; for they observed, with a female \textit{Loligo}, numerous Spermatophores glued to the internal surface of this cavity, near the oviduct.
still at the bottom of the female genital organs; for, later, the action of the sperm would be obstructed by their solid envelopes. It must, therefore, be supposed that the sperm is carried from the cavity of the mantle into the ovarian capsule, either by means of the anti-peristaltic movements of the oviduct, or by the aid of the aquiferous system.\(^5\)

\section*{§ 260.}

With the individuals hitherto known as the \textit{Hectocotyla}, the genital organs occupy a space disproportionally large to the size of the body. The round, smooth enlargement on their posterior extremity is a genital capsule, with thin walls, and containing the sperm and the copulatory organs.\(^4\) The sperm forms a long, moniliform, clustered string, composed of thick oval bundles of spermatid particles, regularly bound together by fasciculi of hair-like spermatid particles.\(^6\) In this clustered string are included, also, the \textit{Ductus ejaculatorius} and the very long and retractile penis. With \textit{Tremoctopus violaceus}, this penis sometimes projects between the fifth of the posterior pair of suckers, as a small cylindrical, folded prolongation.\(^6\)

\section*{§ 261.}

The Development of the Cephalopoda is almost without analogy, and, from the remotest times, has excited the curiosity of Naturalists; but it is only very recently that it has been correctly understood and followed from its first stages.\(^6\)

After the disappearance of the germinative vesicle, the vitellus divides; but this segmentation is only partial. Usually, at the acute extremity of the vitellus, where the germinative vesicle is found, there appears a small elevation from the vitelline mass, divided into halves by a furrow. Each

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5 According to \textit{Kolliker} (Entwickel. $\&c$. p. 11), the eggs are fecundated while yet contained in the ovarian capsules.


7 I have so observed it with the males of \textit{Tremoctopus violaceus}; and \textit{Dujardin}, also (Hist. Nat. d. Helminth. p. 442), has observed a smooth cord composed of capillary spermatid particles with \textit{Hectocotyla octopoda}, &c.

8 I am uncertain as to the origin of this cord, but, in the specimens preserved in alcohol, which I have examined, it appeared probable that it was primarily contained in the deferent or in the testicular canal.

9 The \textit{Ductus ejaculatorius} of \textit{Tremoctopus violaceus}, which is gradually continuous into the penis, begins by a well-marked, clavate thickening, projecting into the genital capsule, and apparently perforated at its upper extremity, at which point, perhaps, the sperm enters. Near the end of the penis, this cord has, over a considerable extent, small horny tubercles, and it is probable that this portion can be evaginated, thus allowing the possibility of an intimate union with the female organs. I am unable to say whether this is so with the other \textit{Hectocotyla}. The penis of \textit{Hectocotyla argonauta}, according to a figure of \textit{Delia Chiop} (loc. cit. Tav. XV, fig. 1, a), and Coster (loc. cit. Pl. XIII, fig. 2, 6), projects from the posterior extremity of the body; but it may be, that with the specimens examined by these naturalists, this organ had become free from an accidental rent of the genital capsule.

10 \textit{Aristotle} (Hist. Animal, lib. V, cap. 16, 4), and in the last century, \textit{Chiaje} (Abhandl. über die Erzeugung der Fische u. d. Krebses, 1732, p. 54) had already declared that, with \textit{Sepia}, the vitelline sac is situated on the head of the embryo, and, as it were, hanging from the mouth; but it is only lately that this statement has been thoroughly verified; see \textit{Froriep}, Das Takerichi, Abh. V. 1806, p. 28, fig. 5-10; \textit{Carus}, Erfahrungenstaf. Hdb. IV, 1831, p. 10, Taf. II., fig. 16-30; \textit{Cuvier}, Sur les œufs de Séche, in the Nouv. Ann. du Mus. 1832, p. 135, Pl. VII., t. 6-14, also in abstract in Ann. d. Sc. Nat. XXVI. 1832, p. 69, or \textit{Froriep}\textquoteleft s Notices XXIV. p. 198; \textit{Coldstream}, On the forums of Sepia officinalis, in the Lond. and Edinb. Phil. Mag. Oct. 1823, or \textit{Froriep}\textquoteleft s Notices XXXIV. p. 6; \textit{Dugas}, Note sur le développement du Penbomyone chez les Moluques, Cephalopodes, in Ann. d. Sc. Nat. VIII. 1837, p. 107, Pl. X., or \textit{Froriep}\textquoteleft s new Notices VI. p. 204, fig. 3-5; \textit{D\'Orbigny}, in \textit{Furisse}, loc. cit. \textit{Cuvier}, Pl. X., fig. 3-6; \textit{Van Beneden}, Recherches sur les Penbomyones des Sepoles, in the Nouv. Mem. de l\textquoteleft Acad. de Bruxelles, XIV. 1841, Pl. I., \textit{Delia Chiop}, Decrip. L, p. 29, Tav. VI., fig. 6, 7 (Sepia), Tav. XIV., fig. 11-21 (Aronuata), and Tav. XXIX., fig. 2-5 (Sepiata). But the first phases of their development remained unobserved, until \textit{Kolliker}, in 1834, filled this deficiency by his masterly work — \textit{Entwicklungsgeschichte} der Cephalopoden.
of these halves is also divided, and so on, forming four, eight, &c., segments, each resembling a more and more acute triangle, with a converging apex, while its base is directly continuous with the remaining vitellus. After a certain number of segments have been formed by these longitudinal divisions, transverse furrows are seen separating the apices of the segments, and forming, at first, in the centre of the eminence, a ring composed of eight to sixteen portions; but finally, from a further segmentation in both directions, these furrows become a mass of increasingly smaller and more numerous parts.  

This portion of the vitellus, which, during this time, has also been developed at its periphery, is changed into a blastoderma composed of two layers. Upon this blastodermal membrane several folds appear, which are the first traces of the future embryo, viz: first, a median, uneven fold or rudiment of the mantle, and then two others, lateral, which ultimately form the eyes. Between these three folds are placed two others which become the two lateral halves of the funnel. Subsequently, the folds of the branchiae and arms appear; and among these last two belonging to the ventral surface are first seen. Still later, the folds of the eyes and arms, and their surrounding parts, become more and more prominent upon the vitelline mass, thus forming the cephalic portion of the embryo. From this last, opposite the vitellus, the fold of the mantle is sketched as the future posterior portion of the body. The general form of the animal may, therefore, be recognized very early, although the cephalic portion quite exceeds that of the mantle.

At the posterior or dorsal surface of the cephalic portion, the mouth appears, first as a semilunar depression, and the internal layer of the blastoderma gradually extends from the border of this portion over the whole vitelline mass, producing, finally, a true vitelline sac. The external surface of this is covered with ciliated epithelium which gradually spreads over the other parts of the embryo, such as the lobes of the head, the arms, the eyes, and the mantle, while that of the branchiae, and the funnel, the halves of which have then united, is never ciliated.

Of the Cartilages, the articular and cephalic are the first developed. The internal shell, the nervous system, the heart with the vascular and respiratory systems, the digestive canal and its appendages, are formed successively, and may be easily seen at the termination of the embryonic life, when, also, are found some chromatid cells.

As to the vitelline sac, it should be remarked that it never communicates with the intestinal canal, as has hitherto been supposed. The cephalic portion, which always extends upon this sac, embraces a part of it, so that it is divided by a constricting into an internal and external portion, the former of which extends even into the cavity of the mantle. The constricted portion is gradually elongated, and finally becomes a long, very narrow canal, extending from the cephalic extremity to the side of the

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2 See Kolliker, loc. cit. p. 17, Taf. I.
3 With Loligo, the vitelline sac and its ciliated epithelium are formed quite early; while with Sepiola, they do not appear until the embryo and its different organs have become quite large. With the first, the embryos have rotary movements, but, with the second, this is not the case (Kolliker, loc. cit. p. 54).
4 With Arionauta, the external shell is formed while the embryo after its escape from the egg, is still persistent in the spawn inside the shell of its parent; see Power, in Wiegmann's Arch. 1845, i. p. 373, and Maravigno, Ann. d. Sc. Nat. VII. 1837, p. 174.
5 Of the earlier anatomists were led into error from the tenacity of the canal of communication, and the difficulty of its examination. They supposed that the external vitelline sac communicated with the esophagus and stomach, by this canal; see Carius, loc. cit. Taf. II. fig. 21 (Loligo); Cuvier, loc. cit. Pl. VII. fig. 9 ; Jurgès, loc. cit. Pl. V. fig. 5 (Sepiola) and Van Beneden, loc. cit. Pl. I. fig. 13 (Sepiola). Kolliker was the first to view it correctly (loc. cit. p. 56, Taf. IV.).
mouth, and producing a communication between the internal and external sacs.

The vitellus of the internal sac gradually disappears, and is replaced through this canal of communication by that of the external sac. During the successive development of the organs contained in the cavity of the mantle, the internal vitelline sac is divided into lobes which are finally broken up and absorbed; while the intestinal canal, the remaining organ of the embryo, is developed, quite independently, from the vitelline mass.

As to the development of the males (Hectocotylus) of Argonauta and Tremoctopus, nothing is yet known except of its last period. It has been observed, however, that, during the time they are in the egg, they have their proper form which is so remarkably different from that of the females.6

6 Had the fact that the Hectocotylus exist in the egg with their proper form, among the eggs of females of certain species, been properly observed, the true relations of these supposed parasites to the animals in which they live, would have been known long ago. A passage of Maravigno, first properly interpreted by Kulikier (Ann. of Nat. Hist. loc. cit. p. 414) shows clearly that this Italian naturalist, in his researches connected with Argonauta, was in error only as to the eggs which contained the male individuals.

* [§ 261, note 6.] The subject of the Hectocotylus to which such frequent mention has been made in these pages, is one that has elicited a good deal of attention of late years, but, now, happily, seems pretty definitely settled. Chief among these investigators are H. Müller, and Verany and Vogt. They have pretty clearly shown the non-independent character of these forms. The details of these researches cannot here be given; it may be remarked, however, that these observers have all studied these forms upon living specimens on the coast. It has been shown that the Argonautae on which these Hectocotylus are found, have a highly-developed testicle, the situation and structure of which correspond to those of the common Cephalopoda, and which communicates with the Hectocotylus.

In conclusion, I may quote H. Müller's own words: "It is then proved that the Hectocotylus is formed on a male Argonauta, and is nothing but an arm metamorphosed in a very irregular manner. This arm, or the Hectocotylus, is detached when it has been filled with the sperm which is formed in a true testicle of the Argonauta itself, and it then plays an apparently independent life. In this condition it meets the female Argonautae which, by a true copulation, it impregnates, as I have observed with the Hectocotylus of a Tremoctopus, and it resembles in this, as also by its movements, by a kind of circulation, and by the long duration of its life after detachment, a true male animal."

INTRODUCTORY NOTE TO THE CRUSTACEA.

Within a short time, the class Crustacea has received a contribution of so valuable a character that I cannot omit to mention it specially in a note. I refer to the large and comprehensive work of Dana, published this year (1853). This work, aside from its high zoological value, includes anatomical details and the discussion of principles in animal morphology, of great importance to the student of this interesting yet difficult class of animals.

It will be found that constant reference has been made to the anatomical details, in my notes; but the doctrines advanced as to the morphological structure of these animals, more than equally important, could be here given only in a separate form. I have been the more induced to include them here, from the fact that the work in question will have a very limited circulation, comparatively, and can be accessible only to a few. With these views, I have solicited Professor Dana to put his particular principles into a condensed form for this work, and he has kindly favored me with the following account:

The several types of structure among Crustacea are distinguished, primarily, by the different degrees of centralization or cephalization in the species, which degrees of cephalization are exhibited in the form of the body, and position, number, form or length of the appendages. The higher cephalization is seen in the larger number of organs that are pressed into the service of the senses and mouth; in the closely-crowded position and small size of these organs; in the little elongation of the antennae; and in the obsolescence of the abdomen and absence of abdominal appendages. Thus, in the Brachyura, nine segments and their pairs of appendages, out of the fourteen cephalothoracic, belong to the senses and mouth; they are all small, and gathered into a short space; the antennae are exceedingly small, excepting the basal joint which is the seat of sense; the abdomen in the males is small and without appendages. In the Maioids, the highest Brachyura, the head is very narrow, with the anterior antennae longitudinal, and the base of the outer antennae soldered without suture to the shell. The concentration is here most complete. The widening of the front in the Cancroids shows a relaxation of the concentration,
as do also other characteristics; the loosening of the outer maxillipeds in the true Cancers, and most swimming Crustacea and Corystoids, is another step in this relaxation; the elongation of the antennae in the Corystoids and Anomoura is another step; the loosening of the abdomen from the ventral surface of the cephalothorax; its becoming loosely inflected or even extended; its taking appendages — are among the other steps seen in the Anomoura; the outer maxillipeds becoming pediform, and then the next pair pediform also, showing a tendency to a passage from the mouth-series to the foot-series, are other steps downward, observed in the Macrura; and the elongated abdomen with its regular series of organs as well as the elongated antennae, the union without fossettes, and eyes without sockets, all exhibit the relaxation of centralization that marks the Macrura.

A further degradation is seen in the obsolescence of some of the pairs of feet and abdominal appendages, as in the Mysis group; and the same principle is exemplified in the Brachyura, where the posterior cephalothoracic legs become small or rudimentary, or swimming legs.

There are, hence, two methods by which the passage of Crustacea from the higher to the lower grades takes place:

1. A diminution of the centralization leading to an enlargement of the circumference or sphere of growth at the expense of concentration, as in the elongation of the antennae, a transfer of the maxillipeds to the foot-series, and the elongation of the abdomen and abdominal appendages.

2. A diminution of force as compared with the size of the structure, leading to an abbreviation or obsolescence of some of the circumferential organs, as the posterior or cephalothoracic legs, or anterior antennae, or the abdominal appendages (if such appendages belong to the type embracing the species).

The Macrura, Anomoura, and Brachyura are alike in having normally nine cephalic annuli (out of the fourteen cephalothoracic), and but five foot-annuli. The Mysis and Squilla groups are in the same category. There are species that show a tendency to a transfer of the posterior mouth-annuli or appendages to the foot-series, but it is only a tendency. These together constitute the First type among Crustacea.

In the Second type, there are seven cephalic annuli and pairs of appendages, and seven foot-annuli or pairs of feet; such are the Isopoda, Anisopoda and Amphipoda.

In the Third type, there are normally six (or five) cephalic annuli, out of the whole normal number, fourteen, — the eight (or nine) posterior annuli belonging to the foot-series, part of which (the three posterior pairs and often more) are usually obsolete. Moreover, the abdomen, by the second law of degradation, mentioned above, is without appendages — such are the Entomostracea.
In the **Fourth type**, there are six (or five) cephalothoracic annuli, as in the Entomostraca, with which group they might be associated. But other peculiarities lead to a separation, and the species referred to are the Cirripedia.

In the **Fifth type**, there are five (or four) cephalothoracic annuli, out of the whole normal number fourteen; in other words, the mouth never includes more than a single pair of maxillae with the mandibles. Moreover, by the second law of degradation, all the jointed cephalothoracic appendages are wanting. These are the Rotatoria.

The following table presents a view of the number of cephalic annuli in these Types, and also the mean size:

<table>
<thead>
<tr>
<th>Type</th>
<th>Typical No. of cephalic annuli</th>
<th>Mean normal length in lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Decapoda or Podophthalmia.</td>
<td>9 24 (and breadth 24).</td>
<td></td>
</tr>
<tr>
<td>Sub-type I. Brachyura,</td>
<td>7 6</td>
<td></td>
</tr>
<tr>
<td>Sub-type II. Macrura,</td>
<td>6-5 1</td>
<td></td>
</tr>
<tr>
<td>II. Tetradecapoda,</td>
<td>6-5 1</td>
<td></td>
</tr>
<tr>
<td>III. Entomostraca,</td>
<td>5-4 1-9</td>
<td></td>
</tr>
<tr>
<td>IV. Cirripedia,</td>
<td>5-4 1-9</td>
<td></td>
</tr>
<tr>
<td>V. Rotatoria,</td>
<td>5-4 1-9</td>
<td></td>
</tr>
</tbody>
</table>

See pp. 1406 and 1407 (loc. cit.), for observations on mean size in the Entomostraca and Cirripedia, where an important principle is brought out, and where, also, some explanations are furnished which make the statement given above of the mean size, intelligible. — Ed.
BOOK TWELFTH.

CRUSTACEA.

CLASSIFICATION.

§ 262.

In the Classification of the Crustacea, the remark of Erichson\(^1\) should be adduced, that, with these animals, the external locomotive organs are not limited, as with the other Arthropoda, to the anterior part of the body, but may exist on all its segments, and often with a shape so changed, that they become foot-jaws, or anal-feet, or ears. If the Crustacea are examined from this point of view, it will not appear surprising that the Myriapoda are classed among them; for they do not properly belong either to the Arachnoidae or to the Insecta.

ORDER I. CIRRIPEDIA.

Family: Balanodea.
Genera: Balanus, Chthamalus, Coronula, Tubicinella.

Family: Lepadæa.
Genera: Otion, Cineras, Lepas, Pollicipes.

ORDER II. SIPHONOSTOMA.

Family: Penellina.
Genera: Penella, Peniculus, Lernaeocera, Lernaea.

Family: Lernæodea.
Genera: Achtheres, Tracheliastes, Brachiella, Lernæopoda, Anchorella, Chondracanthus.

Family: Ergasilina.
Genera: Dichelestium, Lamprolena, Ergasilus, Nicothœ.

\(^1\) Erichson, Entomographien, Hft. I. p. 12.
Family: Caligina.
Genera: Caligus, Pandarus, Trebion, Dinematura, Euryphorus, Phyllopodora.

Family: Argulina.
Genus: Argulus.

ORDER III. LOPHYROPODA.
Genera: Cyclopsina, Cyclops, Anomalocera, Calanus, Peltidium, Hersilia, Polyphemus, Daphnia, Eucadne, Lyncus, Cypris.

ORDER IV. PHYLLOPODA.
Genera: Lynmadia, Isaura (Estheria), Apus, Branchipus, Artemia, Chirocephalus.

ORDER V. POECILOPODA.
Genus: Limulus.

ORDER VI. LAEMODIPODA.
Genera: Cyamus, Caprella, Leptomera, Aegina.

ORDER VII. ISOPODA.
Family: Bopyrina.
Genera: Bopyrus, Phryxus, Jone, Cepon.

Family: Cymothoidea.
Genera: Cymothoa, Aega, Nerocila, Anilocra, Serolis.

Family: Sphaeromatoda.
Genera: Sphaeroma, Cymodocea, Nesea, Amphoroidea.

Family: Idotheoidea.
Genus: Idothea.

Family: Asellina.
Genera: Lygia, Janira, Asellus, Lygidium, Porcellio, Oniscus, Armadillidium, Tylos.

ORDER VIII. AMPHIPODA.
Genera: Vibilia, Hyeria (Hiella), Phronima, Iphimedia, Amphithoe, Talitrus, Gammarus.

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ORDER IX. STOMAPODA.

Genera: Phyllosoma, Amphion, Mysis, Leucifer, Cynthia, Thysanopoda, Altima, Squilla, Squillerichthus.

ORDER X. DECAPODA.

SUB-ORDER I. MACRURA.


SUB-ORDER II. ANOMURA.

Genera: Pagurus, Porcellana, Remipes, Ranina, Homola, Lithodes, Dromia, Dorippe.

SUB-ORDER III. BRACHYURA.


ORDER XI. MYRIAPODA.

SUB-ORDER I. CHILOGNATHA.

Genera: Glomeris, Blaniulus, Platyulus, Polydesmus, Spirobolus, Julius.

SUB-ORDER II. CHILOPODA.

Genera: Cryptops, Geophilus, Scolopendra, Lithobius, Scutigera.

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Darwin. A monograph of the sub-class Cirripedia with figures of all the species. Published by Ray Soc. London, 1851. This work is rich in anatomical details, many of which are new.


CHAPTER I.

EXTERNAL ENVELOPE AND CUTANEOUS SKELETON.

§ 263.

The External envelope of the Crustacea is more or less solid, and has the form of a multi-articulated, cutaneous skeleton, sometimes of a leathery or horny consistence, but generally consists of a hard, calcareous shell.

It has, consequently, no contractility, and participates in the movements of the body only in a passive manner, that is, by the interarticular soft skin, and by the antennal and foot-like processes.

In this cutaneous skeleton, whether it is leathery, horny, or calcareous, there is a peculiar organic substance as its base. This substance, which is found in the cutaneous skeleton of other Arthropoda also, has received the name of Chitine. It resembles cellulose in plants in its insolubility in caustic potash, but differs essentially from it in containing nitrogen.\(^1\)

§ 264.

Nothing in general can be said as to the Histological composition of this cutaneous skeleton of the Crustacea, for it differs widely not only in the various orders and families, but even in the different parts of the body of the same species.\(^2\) Whether hard or soft, it is usually composed of

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\(^1\) This Chitine which was formerly taken for a horny substance, was first discovered with the insects by Odier (Mém. d. l. Soc. d'Hist. Nat. de Paris, t. 1824, p. 22). Latterly, it has been carefully investigated by C. Schmidt (Zur vergleich. Physiol. d. Wirbellos. Thiere, 1843, p. 362), who found, moreover, that the cutaneous skeleton of Crustacea has the same composition as that of insects.

\(^2\) [§ 264, note 1.] Of the results of Lavalle's observations it may be well to add his concluding remarks; after a minute description of each portion of the tegumentary apparatus, he concludes:—

I shall here only observe further, that my investigations seem to be in complete opposition to the theories which make the shell of the Crustacea analogous (homologous) to the scaly epidermis of Serpents and Lizards. I see no analogy (homology) between the shedding of the shell of the Crustacea,—which divests them of organs designated to give the body its form and volume, to serve as points of attachment to the locomotor muscles, to furnish the instruments of prehension and mastation; organs placed not only on the surface of the body, but often immersed in the midst of soft parts, and in which we find an organization such as I have described,—and the periodical shedding observed in reptiles of a thin epidermis, without consistency, completely unorganized and incapable of fulfilling any of the uses to which the shell is destined. My re-
numerous very thin layers, made up of very fine, interlaced fibres. However, sometimes this fibrous texture is scarcely distinguishable, and often the lamellae are perfectly homogeneous. Frequently, also, these lamellae are traversed, either in a parallel or perpendicular direction, by canals, which are often so small that, seen under the microscope by reflected light, they appear only as lines or black points. In some species, this skeleton has a distinct cell-structure; for the skin, here and there, has the aspect of a net-work composed of numerous round, or polyhedral meshes.

This net-work is, undoubtedly, the result of the fusion of the walls of numerous cells lying on the same plane. In the calcareous shells, the carbonate and phosphate of lime is so intimately combined with the chitine, that their particles, as such, cannot be distinguished. In those portions of the skin which serve a respiratory function, the calcareous matter is always wanting.

The pigments are due to very fine granules which exist either as such in the cutaneous lamellae, or are so thoroughly fused in these last, that they are indistinguishable. In some cases, these granules are contained in polyhedral cells which form a simple layer under the transparent skin; in others, radiating pigment cells, isolated, or reticulated, are seen through the colorless skin. The red, green, or blue color of many of the lower Crustacea, is due to oil-globules in the interior of the body, which are seen through the transparent integument.

The tubercles, points, bristles, single or bifid hairs, which are usually hollow and exist on the surface or borders of different parts of the cutaneous skeleton, are always mere prolongations or simple excrescences of the integument, and contain its characteristic substance,—Chitine.

With Crustacea, as also with the other Arthropoda, the cutaneous envelope, whatever may be its tenuity,—as for instance on the respiratory organs, is never covered with ciliated epithelium. This absence of vibratile organs is due, probably, to the presence of chitine.

The internal surface of this envelope is usually lined with a peculiar, thin, fibrous membrane, analogous to an internal periostracum. In the moulting process, which is common to all Crustacea, it plays an important part, for it probably secretes, in layers, the materials for the new envelope.

§ 265.

Beside the cutaneous skeleton, there is, with the Cirripedia, an envelope, entirely resembling the mantle and the valves of the Acephala.

2 Astacus, Apus, Julius, and Glomeris. But in the last two of these, the cutaneous canals are pretty large and consequently have not the appearance of black lines.
3 According to Valentin (loc. cit. p. 121), the cutaneous canals of the Astacus fluviatilis are filled with carbonate of lime, a point which I have not had the opportunity to confirm.
4 Cyclops, Cyclopsina, and other Entomosorica.
5 Templeton (Trans. of the Entomol. Soc. L. p. 105, Pl. XXI. fig. 9, a. b.) has observed with Callinectes arietus (an annulacete allied to Cyclopsina castor), two bristles at the extremity of each of the long antennae, and which, he says, are provided with a row of vibratile cilia. But this observation does not invalidate what I have remarked in the text, for how often have ciliary phenomena been observed on organs which really have no such appendages. I doubt if this observation of Templeton will be confirmed by other observers.

searches have exercised me of the vitality of the shell, at least in the first period of its existence; and in reference to this, I am fully of Cuvier's opinion, when he said, in his 'Anatomie Comparée,' 'The envelope of the Crustacea is at first, soft, sensible, and even furnished with vessels, but a quantity of calcareous mole soon collects there, hardens it, and obstrues the pores and vessels'; see loc. cit. p. 376, also Comp. rend. 1347, XXIV. p. 12 — Ko.
The body of these animals, as well as its articulated appendages, are enclosed in a cutaneous skeleton containing the chitine; and, moreover, is enveloped in a peculiar mantle having, externally, calcarious plates which vary in number and are so united together as to be movable in some species, and fixed in others. With the Lepedae, the mantle is prolonged into a kind of siphon.* Not only this mantle, but also its ligaments uniting the movable pieces of the shell and the siphon, are composed of a lamellated tissue analogous to that of the proper cutaneous skeleton, and like it also, contain chitine. It is covered with a thin layer of dark-colored pigment cells.

But the valves of the Cirripedia differ essentially from the calcarious shell of the other Crustacea. In the first place, they have no participation in the moulding, to which the cutaneous skeleton and the mantle are regularly subjected; (3) then again, their structure and chemical composition resemble that of many of the Bivalvia. The valves of the Balanoidae form the only exception in this respect. They are traversed, in part, by numerous parallel tubes, dilated at their interior or their external portion, which pursue a vertical course in the vertical valves, but are radiated in the horizontal plate. These tubes, which are wanting in the movable opercula of these shells and in the transversely-striated valves which, in the genus Balanus, are intercalated between the longitudinally-striated ones, are often laterally compressed, and their interior has imperfect longitudinal septa, or is even divided into several chambers by transverse partitions. The horizontal plate which forms the base of the shell, is perforated centrally, and hollowed on its under surface, with the genus Coronula. This cavity is divided, by numerous vertical and symmetrically-arranged septa, into compartments filled with a fibrous substance. With Tubicinella, this plate is entirely wanting, and is replaced by a fibrous substance. This fibrous matter, by which Coronula and Tubicinella are fixed firmly to foreign bodies, is comparable to the pedicle of the Lepedae, which has become internal and overgrown by the shell.

The increase of the shells of Cirripedia follows the same laws as that with the bivalve or multivalve molluscs, judging from the course of the lines of growth which they present.

§ 266.

The form and number of the different segments of the cutaneous skeleton, which are sometimes extraordinarily developed, and sometimes equally

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1 Thompson (Zool. Research, &c. p. 79, Pl. X. fig. 1), has observed with Balanus puellus, that the Cirripedia, like the other Crustacea, cast off their entire skin at certain seasons. I have myself often seen this animal deprived of its skin with all the appendages, and even the mantle which lines its shell. In captivity, these little animals repeat this process at irregular and often very short intervals, as in twelve, eight and even five days.

* [§ 265.] With the Anatifae, the siphon or pedicle corresponds to a pair of antennae in the young; the animal attaches itself by the sucker-like disc terminating these organs, before the metamorphosis commences, and in a group of these animals all the different stages may be observed,

2 See Schmidt, loc. cit. p. 60.
3 See Poll, loc. cit. Tab. IV. fig. 6-10; Rapp, in Wiegmann's Arch. 1841, I. p. 103; and Coldstream, in the Cyclop. of Nat. loc. cit. p. 655.
4 For Coronula diodrom and balaninaris, see Chemnitz, Novum Conchylium-Cabin. VIII. p. 319, Tab. XCIX. fig. 844, 846; Lamarck, Ann. du Mus. d. Hist. Nat. I. p. 461, Pl. XXX. fig. 5, and Burmeister, Beiträge, &c., p. 34, Tab. 1. figs. 2, 8, from the pair of distinct antennae to the fixed simple pedicle; see Dana, Notice of some Genera of Cyclopaeon, Stillicom's Jour. Vol. 1. 2+4 Sc. p. 223, note, also Rep. on Crustacea, Ex. Exped. of the U. S. p. 136.—Ew.
The voluntary muscles of Crustacea are composed exclusively of transversely-striated fibres, and are, moreover, perfectly colorless.\(^1\)

They are always inserted upon the interior of the skeleton, either directly, or by means of its prolongations. These last are often very long, resembling tendons; from which, however, they differ in their intimate structure and chemical composition. They are composed of straight, parallel, flattened fibres, and show their direct relations with the cutaneous skeleton by containing chitine.

The isolated muscles have usually a ribbon-like form,\(^2\) and are especially accumulated in those regions of the body displaying great power or extensive movements. There are, therefore, for their reception, cavities or large canals in certain parts of the skeleton. Generally, the flexors are upon the ventral, and the extensors on the dorsal surface of the body. The first are always larger and more powerful than the second. Usually, the muscles pass from one segment to the adjacent one, and by this arrangement, the interarticulare movement between the segments is produced. Their course is longitudinal, but, especially where there are several superposed layers, they assume also an oblique and crucial direction.\(^3\) Rarely are transverse muscles observed.\(^4\)

The muscular system in general is very unequally developed in the various orders of Crustacea. It is most complicated when the number of

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\(^1\) See Savigny, Mem. ic. part I. and Eriochon, Encyclopaedia. III. 1, 1840, p. 1, Taf. II.

\(^2\) For the muscles of *Aestus*, see Will, in Muller's Arch. 1843, p. 538.*

\(^3\) In the tail of many Decapodes, and in the abdominal segments of Myriapoda.

\(^4\) With the Myriapoda, the transverse muscles pass off right and left from the ventral median line to the sides of the abdominal segments. With the Ermneas, and Errigalina, there are, under the skin, transverse as well as longitudinal muscles.

\(^5\) For a circular muscle quite extraordinary in *Caligus*, see Dana, Descript. of a species of Caligus, Amer. Jour. of Sc. XXXIV. p. 247, Pl. IV. fig. 7, r. — Ed.

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abortive and fused several together, — serve, in descriptive zoology, to characterize orders, sub-orders, families, and genera; consequently they need not be mentioned here.\(^6\)

With many Crustacea, the internal surface of the skeleton in widely different parts of the body, has prolongations and processes of the most manifold form; some of these serve as points for the insertion of muscles and tendons, and others as partitions separating and shielding particular organs.

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CHAPTER II.

MUSCULAR SYSTEM AND ORGANS OF LOCOMOTION.

§ 267.

The voluntary muscles of Crustacea are composed exclusively of transversely-striated fibres, and are, moreover, perfectly colorless.\(^1\)

They are always inserted upon the interior of the skeleton, either directly, or by means of its prolongations. These last are often very long, resembling tendons; from which, however, they differ in their intimate structure and chemical composition. They are composed of straight, parallel, flattened fibres, and show their direct relations with the cutaneous skeleton by containing chitine.

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§ 268. THE CRUSTACEA.

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the segments of the body is greatest; \(^4\) and most simple when these segments are atrophied or blended together. \(^5\)

§ 268.

The locomotive organs of the Crustacea are, in general, very numerous; for, often all the segments, from the head to the extremity of the tail, that is, the three corresponding to the thoracic segments of insects, and those of the posterior part of the body, have, each, a pair of articulated appendages. In the order Myriapoda, the Chilognatha have two pairs of legs on each segment of the body. \(^1\) The form of these organs may be most variously modified, and even so much so that their function is entirely changed. \(^2\) But those of the first five segments of the abdomen are most constant in their form; although they change their function, being sometimes ambulatory legs, sometimes prehensile organs, and sometimes oars. When prehensile organs, their last joint is armed with a very hooked, sharp claw; when oars, this same joint becomes a plate bordered with stiff bristles or bifid hairs.

The locomotive organs of the three thoracic segments are usually pressed towards the mouth and changed into foot-jaws, which serve either as masticatory, or as tactile and prehensile organs. The appendages of the posterior part of the body may have even yet wider variations. They may be changed into false or abdominal feet serving sometimes as oars, as fines, or as respiratory organs; and, in the act of generation, they may play the part, some, of copulatory organs, and others, as porters of the eggs.

When they are ambulatory, or when prehensile organs, these appendages may be divided into six pieces, viz.: The Coxa, the Trochanter, the Femur, the Tibia, the Metatarsus, and the Tarsus the extremity of which, with the ambulatory foot, is often prolonged into a short, stiff claw. When they serve as natatory organs, the separate joints are more or less flattened and spread out. When used as prehensile organs, they are either monodactyle — the entire tarsus being transformed into a strongly-curved hook which can be applied against the metatarsus, — or they are didactyle or like pincers, — the metatarsus being thickened or increased in a hand-like manner, and prolonged into an immovable process (Index), against which the tarsus (Pöllcz) can be applied in a finger-like manner.

From these metamorphoses and the complete abortion of these appendages, the various forms of Crustacea may be reduced to a few principal types, as follows:

\(^4\) The muscular system is highly developed with Decapoda, Somapoda, Amphipoda, Isopoda, Myriapoda, Pocillopoda and Phyllopoda; see Grec xls, De Cancri antenn quinquies, parth. p. 7, fig. 1—7; Suckow, Anat. physiol. Untersuch. loc. cit. p. 64, Tab. IX. X. (Astacns fluviatilis); Milbe Edwards, Hist. Nat. d. Cricket, l. p. 153, Pl. XIII. (Homarus marinus); Kutorza, Scala-pendr, morscher Anat. p. 12, Tab. II. fig. 1, 2; Van der Hoeven, Rechoucha, sur l'héist. nat. et Fumit. d. Limusi, p. 24, Pl. III.; Zaddock, De Apolis cernicornis Anat. p. 4, Tab. I. III.

\(^5\) The abortion of the muscular system is often so extensive in the lower parasitic Crustacea, that, beside the few muscles belonging to the tactile and locomotive organs, there are found only some longitudinal and transverse fibres under the skin; see Nordmann, Microgr. Beiträge, Hft. 3, p. 6, Tab. I. V. VII. (Lampropleura, Aethecea and Trachelistes); Rathke, in the Nov. Act. Nat. Cur. XIX. p. 141, Tab. XVII. fig. 2. 3 (Dichela- tism); Pickering and Dana, in the Ibis, 1841, Tab. IV. (Cottus).

\(^1\) This anomaly, in which the three segments back of the head do not participate, is due, perhaps, to the segments of the body being always fused in two.

\(^2\) In the interpretation of the movable appendages, I have relied for the most part on the principles of Ericson (Entomograph. loc. cit.), for they appear most consistent and unconstrained. In the instances where, at first sight, they appear unwarranted, they may be very well explained by recourse to the phenomena of development of Crustacea; and by this means, here, especially, where the metamorphoses occur gradually and continuously, may be found the solution of many obscure questions in morphology.
1. With the Myriapoda, these appendages are ambulatory and have the same form with all the segments of the body; and only with the Chilopoda the anterior and middle pairs of the first segment corresponding to a thorax, are changed into tactile organs.

2. With the Isopoda, Laemodipoda, and Amphipoda, the first thoracic pair are tactile organs. With the Amphipoda, the second and third thoracic pairs are changed into prehensile organs armed with a claw. The five anterior abdominal pairs are ambulatory and unchanged, with the Isopoda, and Amphipoda. But the remaining posterior pairs are transformed, with the first of these orders, into lamelliform respiratory organs; and with the second, into short, very movable appendages, terminated, each, by a double uni- or multi-articulate cirrus, which serve sometimes as oars, sometimes as gyramory organs.

3. With the Decapoda, the thorax is entirely abortive, and its three pairs are changed into oral and tactile organs; while the first pair, belonging to the anterior abdominal segments, is usually transformed into a forficulate prehensile organ. The four succeeding pairs are simply ambulatory organs. But the appendages of the posterior part of the abdomen are reduced to tendril-like processes, which play a part in the act of generation.

With the Squillina, the three thoracic, and the first two abdominal pairs have the form of prehensile organs, while the three succeeding pairs retain their character of ambulatory organs, and those of the remaining posterior segments are changed into lamelliform fins.

4. In the section of the inferior Crustacea, designated usually under the name of Entomotroaenae, the head and thorax are fused into a single part called Cephalothorax, and the mouth is situated so far behind, that the first pair of feet is in front of it. The locomotive apparatus here consists usually of ears or prehensile organs. With the Poecilopoda, the first three pairs of appendages are forficulate, as, also, are the three pairs of jaws. With the Phyllopoda, and Lophyropoda, the first two pairs of feet resemble antennae; of these sometimes the first, as well as the second, which are usually branched, serve as oars; in here, also, the often very numerous, anterior abdominal appendages are used usually as fins, while the posterior ones are scarcely at all developed.

5. With the Cirripedia, the first thoracic pair is transformed in a remarkable manner. With the Lepadea, they are changed into a soft foot; and with the Balanoea, into a shell. The remaining six pairs are multiarticular cirrate organs, and the abdomen is prolonged into a tail free from appendages. The three anterior pairs of these cirrate organs are the shorter, and have a tactile function; while the three posterior are used as gyrotry organs.

6. With the Siphonostoma, the mouth is even still further behind, and the young animals, these organs are used clearly as oars; see Jurine, Hist. d. Mollusca, loc. cit. Pl. XX. fig. 9, and Pl. XXI. fig. 1. (Chirocephalus), and Joly, in the Ann. d. Sc. Nat. XIII. Pl. VII. (Artemia).*

* [§ 268, note 3.] The first pair of feet is, generally, the second pair of antennae. For a full discussion of this point, see Dana, Report on Crustace. &c. p. 103. — Ed.
the number of appendages much less; so that the three and only pairs, corresponding to the thoracic, are in front of the mouth. With the Caligina, and the Ergasilina, the thoracic appendages are prehensile organs, while those of the abdomen are changed into rudimentary ears. With the genus Argulus alone, the first abdominal pair has the form of suckers,* the remaining ones being fin-like as usual. With the Lernaeodea, the abdominal appendages are entirely wanting, and there are only a few anterior prehensile ones, two of which, in some genera, are prolonged arm-like, and united, at their extremity, into a button-like, suctorial organ.† Sometimes these arms are wanting, there being present only the suctorial organ.‡ With the Penelliida, the locomotive organs are reduced to non-articulated rudiments; or even these may be wanting, and then the cephalic extremity of the unsegmented body has stiff, forked, horny, processes, by means of which these parasites enter the parenchyma of other animals.①

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Certain Crustacea have, moreover, a special locomotive apparatus. With Cypridina, the body is shielded with a bivalve shell, the halves of which move on a kind of hinge. Upon their internal surface are inserted muscular fibres, arising from the back of the animal, which act like the adductor muscles of the bivalve Acetabula.

With the Cirripedia, there is a considerable transverse adductor muscle, which, with the Balanodea, and Lepadida, is situated in the anterior or cephalic angle of the fissure of the mantle, which is nearly always closed by an operculum.② In this same angle, the body, with all the Cirripedia, is in connection with the mantle, partly by its cutaneous envelope, which, at this point, is folded in so as to line the cavity of the mantle, and partly by various muscles. These muscles arise from the anterior extremity of the body, which is inverted within the cavity of the mantle, and from both the ventral (or upper), and from the dorsal (or lower) surface of the animal.

When those of the upper or abdominal surface are contracted, and, at the same time, the adductor muscle of the valves is relaxed, the animal comes out through the fissure of the mantle; but it is withdrawn into the mantle-cavity when those of the lower or dorsal surface are contracted.③

5 Tracheliastes, Achtheres, Brachiella. 6 Anchorella. 7 Lernaeus, Lernaeocera. 1 Poli, loc. cit. Tab. IV, fig. 3 J.; Cuvier, Mém. &c. p. 5, fig. 2, 7 e. 11 A, and Martin St. Ange, Mém. &c. p. 15, Pl. II. fig. 15, 8. 2 Poli, loc. cit. Tab. IV, fig. 13, y. z. 17; Cuvier, loc. cit. p. 5, fig. 18 b. b., and Martin St. Ange, loc. cit. p. 14, Pl. II. fig. 17, 19, J. ① For a very complete description of these sucker-like organs, with excellent figures, see Dana, Amer. Jour. Sc. XXXI. 1837, p. 297, and Rep. on Crustac. loc. cit. p. 13, 13. — Ed.
CHAPTER III.
NERVOUS SYSTEM.

§ 270.

The Nervous system of the Crustacea, is developed in different degrees according to the various orders.\(^1\)

Its central mass consists of an abdominal cord, connecting, usually, with the cerebral ganglia by an oesophageal ring. With the long-bodied species, this abdominal cord is composed of numerous ganglia, arranged in successive pairs from before backwards, and connected together by longitudinal commissures. But when the cutaneous skeleton is shortened by a diminution or a fusion of the segments, the ganglionic chain is lessened in a like manner by a coalescence or a disappearance of several of its ganglia.

With the Myriapoda, the Stomapoda, the Amphipoda, and Isopoda, the abdominal cord consists of ten to thirteen pairs of unequal ganglia, situated, usually, on the median line, and shielded by septa given off from the internal surface of the thoracic and abdominal segments of the skeleton.

The size of these ganglia is in direct ratio with the development of the segments and their appendages, to which they belong. Those of the thorax, — the anterior abdominal ones, as well as the last caudal one, are consequently very large, for they send filaments to the various chelate, prehensile, ambulatory, and nutritory appendages, and to the caudal lamellae, which are usually highly developed. With the Myriapoda, the abdominal cord is remarkable for the great number of its ganglia, which are of equal size. Quite often, the ganglia of the same pair are fused into a single mass; in which case, the two interganglionic commissures are more or less approximated or even blended together. With some species, a portion of the abdominal ganglia are so closely approximated, successively, that the interganglionic commissures are wholly wanting. With the Brachyura, the whole abdominal cord is concentrated into a large central mass.

The peripheric nerves arise from the ganglia, rarely from the interganglionic commissures. The cerebral mass, which is situated above or in front of the oesophagus, is composed of a pair of considerable ganglia, more or less fused together. The nerves sent off from these, go principally to the organs of sense; and in the inferior Crustacea, where these last are wanting, the cerebral mass is absent also. In such case, there are usually wanting likewise the two cerebral commissures, which are given off from the anterior thoracic ganglion, and surround the oesophagus.\(^*\)

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\(^*\) [End of § 270.] It is regretted that no example, illustrative of this last statement, is given, for certainly none is now recollected where the grand typical structure is not present, — in other words, where the oesophagus does not pierce the cerebral nervous system at some point. In many of the inferior Crustacea, such as Caligus, and some of not all of the Cyclops tribe, the cephalic, thoracic, and abdominal ganglia, are fused into a single mass through the anterior part of which the oesophagus passes; see Dana, loc. cit. Caligus. Amer. Jour. Sc. XXXIV. p. 250. — Ed.
The intimate structure of the nervous system in many of the orders of Crustacea, can be made out without difficulty, by dissection and the microscope;\(^1\) for its elements are not as liable to change as in the other classes of the Invertebrata already described.

In many species, there may be observed in the nerves surrounded by a delicate fibrous neurilemma, the primitive nerve-fibres so large that their double contour is easily seen; but these gradually assume a varicose aspect.\(^2\) In the ganglia, the ganglionic globules may be easily seen, as very large, round, and sometimes pyriform cells, having each a disproportionately large nucleolated nucleus.\(^3\) As to the course and arrangement of the nerve-fibres in the interior of the abdominal ganglia, two kinds of these fibres may sometimes be distinguished: the first pass uninterruptedly through all the ganglia successively, and thus contribute to the formation of the longitudinal commissures; but the second pass round among the ganglionic globules, and emerge laterally from the ganglion to form the peripheral nerve.\(^4\)

From a more particular examination of the arrangement of the nervous system in the different orders of Crustacea, the following remarkable facts have been noticed.\(^5\)

With the Macrura, where this system is most highly developed,\(^6\) the abdominal cord is composed of twelve pairs of ganglia, generally blended

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2. Ehrenberg, Uerkannte Struct. &c. p. 50, Tab. VI. fig. 3-5 (Homarus marinus, Astacus fluviatilis and Palinemon squilla). The varicose enlargements are represented too regular in some of these figures. See also, Hannover, Rechert, &c. p. 65, Tab. VI. fig. 76, c. 3. Hannover, fig. cit. p. 67, fig. 75, 76 a. (Astacus fluviatilis), and Valentin, in the Nov. Act. Acad. Nat. Chr. XVIII. p. 210, Tab. IX. fig. 72-75. This last author declares that he has observed, in the abdominal ganglia of the common crawfish, the ganglionic globules divided symmetrically into two groups, right and left; and in the caudal gan- glia of the same species, that he has seen two double groups, two anterior and two posterior.
3. Valentin (loc. cit. p. 211) has seen these two kinds of primitive fibres in the abdominal cord of the common crawfish. We are indebted to New- port for very careful observations on the disposition of the nervous fibres in the abdominal cord of Myriapoda, and illustrated by numerous figures; see Phillips, Transact. 1843, p. 243, Pl. XI. or in his abstract in Frolicher's neue Notiz. XXVIII. p. 177, or in the Ann. d. Sc. Nat. I. 1844, p. 55, or Annals of Nat. Hist. XIII. p. 223. According to this observer, four fasciculi of primitive nerve-fibres may be ob- served in the ventral cord of the Myriapoda. An upper and a lower, extending longitudinally, contain the one, motor, and the other, sensitive fibres. A third is composed of transverse fibres which pass from one side of the ganglion to the other; and the fourth extends from one ganglion to the next succeeding, by the side of the longitudinal commis- surues. To these last, Newport has given the name of fibres of reinforcement. Each peripheral nerve given off from the abdominal cord, contains fibres from all of these four fasciculi. The associate and reflex motions between the feet of the same pair, are due to the transverse fibres, and the sym- pathy between the posterior and anterior feet is referable to the fibres of reinforcement.
4. If, in proceeding from the higher to the lower species in the description of the nervous system, I have deviated from the plan hitherto pursued, it is because, with the Crustacea, this system, notwithstanding the various forms of the body, is found upon one and the same type, which is not true in any of the preceding classes, as, for instance, in the Aesopha. This type is especially apparent during the young age of these animals, and does not change except from their exterior metamor- phosis, when, often some portions of the nervous system disappear; on this account, this last will be best understood when studied in its primitive state, or from the more perfect forms it presents in the higher Crustacea.
5. For the nervous system of the macrurous Crustacea, see Audubon and Milne Edwards, loc. cit. (Homarus, Palaeon, and Palinurus); Suckow, loc. cit. p. 61, Taf. XI. fig. 7 (Astacus); Brandt, Medizin. Zool. 1. p. 61, Taf. IX. fig. 1, and especially Newport, Philos. Trans. 1854, p. 406, Pl. XVII. fig. 40-42 (Homarurus).
together laterally, on the median line. Of these, the first six pairs, belonging to the thoracic and to the anterior abdominal segments, are the larger, and send off nerves principally to the foot-jaws, to the prehensile, and to the ambulatory organs. The two longitudinal commissures between the anterior abdominal ganglia, are separate; but those between the posterior ganglia are, on the contrary, blended into a single cord. In some species, these commissures are wholly wanting between the anterior ganglia.\(^5\) The brain consists of a single transverse ganglion; from its front and sides pass off several nerves for the antennae, the olfactory organs, the eyes, and the auditory organs; while, from behind, it sends off the two long cords which surround the oesophagus. These last give branches on their course to the organs of mastication, and interanastomose behind the oesophagus, just before reaching the first thoracic ganglion, by a transverse filament.\(^6\)

With the Stomatopoda, the nervous system is composed of a cerebral ganglion, and of about ten abdominal ganglia; of these, with the Squilla, the last six belong to the tail, while the remaining four, anterior, send nerves to the thorax, and to the first three abdominal segments. The size of the first, which sends nerves to the prehensile feet, is due to its being composed of several ganglia fused together.\(^5\) With the Mysina, the five or six largest ganglia belong to the thorax and to the anterior part of the abdomen, and are connected together by short, double commissures.\(^5\)

The genus *Phyllosoma* has two extraordinarily long and very small oesophageal cords extending from the brain to the abdominal cord. The thoracic portion of this last is composed of three pairs of ganglia, blended almost into a single mass; these are succeeded by six pairs of large abdominal ganglia, arranged in two longitudinal rows, and interconnected by six very short, transverse filaments. In the short tail, there are, moreover, six pairs of ganglia, smaller and laterally contiguous, but connected successively by very small longitudinal filaments.\(^6\)

With the Anomoura, which resemble the Brachyura in the abortion of the post-abdomen, the structure of the nervous system confirms this affinity. With *Pagurus*, the anterior portion of the abdominal cord consists only of three ganglia, which send nerves to the foot-jaws, to the cheliform, and to the partially abortive ambulatory feet. But the posterior part of this cord consists of two cords which arise from the third abdominal ganglion, and unite, just in front of the arms, in the fourth and last ganglion.\(^6\) With the genus *Homola*, the five pairs of the anterior abdominal ganglia are fused into a single mass which is perforated through its centre. From the posterior border of this mass a simple nervous cord as rudiment of the posterior part of the ventral cord, passes off to the wholly abortive post-abdomen.\(^6\)

With the Brachyura, the nervous system has only two central masses, one cerebral, the other abdominal. The first sends nerves, as in the other

\(^3\) *Palinurus*, and *Palaemon* (Audouin and Milne Edwards, loc. cit.). In these two Crustacea, there is only a small fissure in the centre of the principal ganglionic mass, after the fusion of the ganglions.

\(^4\) This transverse filament is absent neither with *Palaemon*, *Palinurus*, nor with *Homarus*, and *Astacus*. It was overlooked by Suckow in the crayfish, although distinctly seen by Brandt; see his Medizin, Zoöl. loc. cit., and his Bemerkungen über die Musкусnerven, loc. cit. Tab. 1. fig. 1, 2 K, or Ann. d. Sc. Nat. V. 1836, Pl. IV.

\(^5\) *Cuvier*, Loges &c. III. 1845, p. 330, and Delle Cije, Descri. &c. Tav. LXXXVI. fig. 6.

\(^6\) *Prey*, De Mysids flexuesae nat. p. 9.


Decapoda, to the organs of sense; the second is large, round or oval, and situated in the centre of the thorax,—it is sometimes perforated centrally, and supplies all the nerves of the trunk, beside sending off the two osophageal cords. These cords are connected by the transverse commissure already mentioned, and give off filaments to the organs of mastication. From the posterior extremity of the cord, there arises a simple nervous trunk, free from ganglia, and extending along the median line to the very extremity of the tail.

Among the Amphipoda, the Gammarrina have a brain scarcely larger than the first of the abdominal ganglia; these last, twelve in number, are connected by double commissures, and the posterior ones belonging to the segments of the body which have false feet, are always smaller than the others. With the large-headed Hyperina, the two cerebral ganglia are considerably larger than the abdominal ones, which are ten in number, and of unequal size. Their commissures are contiguous, and the first ganglion, which is the largest, is probably the result of the fusion of two pairs.

With the Isopoda, the abdominal cord, which is connected with the cerebral ganglia by two short osophageal cords, is composed of seven pairs of ganglia, situated in the thoracic and anterior abdominal segments, and connected together, successively, by double commissures. In some genera, the posterior ganglia send off radiating nerves to the partially abortive and partially fused terminal segments. In others, these seven pairs are succeeded by five or six pairs of others, smaller, and which, with Idothea, are connected together by double commissures; but with the genera Cymothoa, Aega and Legidium are contiguous. With many Isopoda, the peripheric nerves are given off, not only from the ganglia, but also from their longitudinal commissures, and the posterior ones are distributed to the dorsal region of the animal.

With the Lademudipoda, the abdominal cord is composed of eight pairs of ganglia, of which the first two are situated in the cephalic segment, one behind the other, and send off nerves to the organs of mastication, and to the first pair of feet,—thus corresponding to the result of the fusion of the first two thoracic segments with the head. The other pairs are connected by very distinct double commissures, which, between the last two pairs, are quite short, thus bringing the last three pairs almost together in the third terminal segment of the body.

With the Myriapoda the ganglia of the abdominal cord are very numerous, and nearly all of the same size. The brain consists, usually, of a
distinct right and left half, upon each of which is a kind of *Gaeglion opticum*, of a size proportionate to that of the development of the eyes. With the Crustacea, the abdominal ganglia are widely separated from each other, but connected by double commissures which are closely approximated, and in some cases, fused together as a ventral cord. With *Lithobius*, and *Scutigera*, there are sixteen pairs of these ganglia; with *Scolopendra*, twenty-two, and with *Geophilus*, fifty to one hundred and forty. Of these ganglia, the first pair, belonging to the two anterior feet, which are changed into prehensile or tactile organs, are much the largest. The size of the others corresponds, for the most part, to the development of the feet.

Of the Chilognatha, the genus *Polydesmus*, the long feet of which are widely separated, is allied to the preceding section of Myriapoda. Above each two pairs of feet, the abdominal cord is enlarged into two successive ganglia, and the medullary mass between them corresponds to a simple longitudinal commissure. With the other Chilognatha, of which the pairs of feet are close together, the longitudinal commissures are wholly wanting, so that the ganglia, of a number corresponding to that of the pairs of feet, form a moniliform cord; and in some Julidae, the striactions of this last are entirely effaced.

The disposition of the nervous system of *Limulus* is remarkable. Its principal mass surrounds the mouth like a ring. From the anterior portion of this, corresponding to a brain, pass off nerves in front, among which the two optic nerves are conspicuous for their length; while its posterior arc, which surrounds the oesophagus, has three transverse commissures succeeding each other. From the lateral portions of this ring, pass off six pairs of large nerves for as many pairs of prehensile feet. From its posterior border arises a large trunk composed of two bands which extend backwards along the median line of the abdomen, furnishing nerves to the fin-like and gill-like appendages, and then separating, terminate in the tail in a ganglion from which are given off many filaments to the neighboring parts, and a very long one which enters the caudal spine.

Of the nervous system of the Phyllopoda, that of the genus *Apus* is the best known. The brain consists of a flattened, quadrilateral body, from the superior angles of which arise the optic nerves, while from the posterior angles pass off the two long, oesophageal commissures. These last, before reaching the thoracic ganglia, are connected by a transverse commissure. Upon the thoracic succeed numerous abdominal ganglia, those of each pair of which, as in the first, are widely apart, but they gradually approximate posteriorly, and at last are fused into a single mass. The two thoracic ganglia, as well as the anterior abdominal pairs,
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are connected together by double, transverse commissures, which, posteriorly, become single, and, finally, wholly disappear. The longitudinal commissures are disposed in a like manner; they are double and wide apart in front, but, posteriorly, approximate and are proportionally shortened, until they fuse together, and then entirely disappear,—the cord terminating in a simple moniliform band which ends above the last pair of feet. The other abdominal segments which have no feet, receive their nerves from two long cords which arise from the twenty-fourth and twenty-fifth abdominal ganglia and accompany the intestinal canal to the last segment of the tail, where they end in a ganglionic enlargement from which are given off several short filaments, beside a long nerve to the two caudal bristles. In the other Phyllopoda, the nervous system is observed with difficulty, probably from its tenuity; and, as yet, only a single flattened cephalic ganglion has been found. With the very small Lophyropoda, these difficulties are even greater, for here there has been observed a multi-constricted, nervous mass, situated in front of the oesophagus, which may be regarded as a cerebral ganglion, since it sends off, in front, several filaments to the tactile and ocular organs; and, behind, two cords which surround the oesophagus, and join, perhaps, in an abdominal ganglion.

Among the Siphonostoma, with Argulus, as with the Lophyropoda, the nervous centre is reduced to a cerebral mass situated above the proboscis,—and composed of three ganglia arranged triangularly. With the other parasitic Crustacea, of which the head and organs of sense have gradually disappeared, the cerebral ganglion always becomes correspondingly less apparent, while the abdominal cord is the more distinct. This is so with the genus Chondracanthus, which has a cerebral ganglion, and in the few segments of the body, several widely separated (laterally) ganglia connected together by longitudinal, double commissures. With Dicte-

27 Brongniart, loc. cit. p. 87, Pl. XIII. fig. 2, 3, n. (Limnadia), and Joly, loc. cit. p. 310, Pl. V. fig. 8, k, and Pl. VIII. fig. 21, n. (Jenius). This last naturalist has been unable to find a cerebral ganglion with Artemia (loc. cit. p. 242).4

4 An analogous brain, divided by constrictions into three ganglia placed in a row, has been figured by Scheffer (Die zackigen Wasserfüße, loc. cit. p. 29, Tab. II. fig. II. 1, 2, 3), by Straus (loc. cit. p. 396, Pl. XXIX. fig. 6, b. d. e. (Daphnia)), and by Loven (loc. cit. p. 151, Taf. V. fig. 5, 4. (Eudonae)).

28 Jurine, Ann. du Mus. VII. p. 447, Pl. XXVI. fig. 11, and Fawcett, loc. cit. p. 14, fig. 1, L., II.1


4 [§ 272, note 27.] The investigations of Leydig (loc. cit. Siebold and Kolliker’s Zeitseh. III. p. 290) have shown that, with at least Artemia and Branchipus of the Phyllopoda, the nervous system is well developed. This system seems, for the most part, to have escaped the observation of former investigators from want of manipulation; Leydig has described it with detail, and divides it, as usual, into a central and a peripheral portion. The first consists of the brain which sends off nerves to the organs of sense (eyes, antennae, &c.) and connects, by two comminatural cords which embrace the oesophagus, with the ventral cord. This cord is composed of eleven (Branchipus), or twelve (Artemia) ganglia, which are connected, successively, by two longitudinal commissures, and, laterally, each, by a double, transverse commissure. Each of these ganglia sends off, from its outer border, three nerves which are distributed to the abdominal organs and appendages, and to the skin.

—Ed.

| § 272, note 29.] The recent researches of Leydig (loc. cit. Siebold and Kolliker’s Zeitseh. III. p. 325) have extended our knowledge of the nervous system with these lower Crustacea. In Argulus, this observer found the central nervous system to consist of a cerebral portion and a ventral cord. The first, or brain, is composed of two parts—one anterior and club-shaped, the other, beneath the first, pyriform and much the larger. This portion connects, by two commissures which embrace the oesophagus, with the ventral cord. This cord is composed of six ganglia. He observed the following distribution of the peripheral portion of the nervous system. From the brain arise the optic nerves, and behind these, two pairs of nerves for the antennae; of the central ganglia, the first, third and sixth give off nerves to the appendages of the body and its internal organs. Leydig found no trace of a splanchic system with these animals. — Ed. |
lestrium, the cerebral ganglion is entirely wanting, but, in its stead, there is a conspicuous thoracic ganglion under the oesophagus, from which passes off an equal number of nerves in front and behind, and which is succeeded, posteriorly, by a large nervous trunk as the abdominal cord. This cord has ganglionic enlargements in the three anterior abdominal segments, and finally divides into two branches which extend to the very extremity of the tail.\(^{(31)}\) With Acilheres, and Peniculus, the nervous centres consist only of two trunks lying on the lower surface of the abdomen, each side of the intestinal canal.\(^{(32)}\)

With the Cirripedia, which are headless, the nervous centre consists of two parallel abdominal trunks, which, in their course, form six to seven ganglionic enlargements from which pass off, laterally, nerves to the cirri. The two anterior ganglia are connected by a nerve which stretches areately over the oesophagus, and sends filaments to the organs of mastication, so that a brain proper is wanting. The last two pairs of ganglia are blended into a single mass, which sends nerves to the cirri, and two filaments into the long tail.\(^{(33)}\)

\[\text{§ 273.}\]

The Vegetative nervous system is distinctly developed with many Crustacea. It consists of a single or of a double Splanchnic nerve.

With the Decapoda, and Squillina, a single splanchnic nerve arises from the posterior border of the brain,—passes over the stomach, at the same time enlarging into one or two ganglia, distributes its branches to the walls of this organ, and, finally, enters the liver right and left.

This nerve is reinforced by two filaments, which, conjointly with the nerves of the masticatory organs, are given off from the ganglionic enlargements of the two oesophageal commissures, and, before entering the splanchnic nerve, send off filaments directly to the lateral walls of the stomach.\(^{(1)}\)

With the Oniscidae, there are two splanchnic nerves. On each side of the small stomach are two ganglia which connect with the brain by a short filament, and send off, posteriorly, small branches to the walls of the stomach.\(^{(2)}\)

With the Myriapoda, there are also two systems of splanchnic nerves.

\(^{(31)}\) Rothke, Beitr. XIX. p. 150, Tab. XVII. fig. 3, 4.

\(^{(32)}\) Nordmann, Microgr. Belr., Hft. 2, p. 72, 109, Taf. V. fig. 7, 9, 6.

\(^{(33)}\) Casier, Mem. loc. cit. p. 11, fig. 11, and Martin St. Ange, loc. cit. p. 18, Pl. II. fig. 8 (Lepas); also Wyman in Silliman's Amer. Jour. XXXIX. 1840, p. 182 (Olton).\(^{*}\)

\(^{*}\) We are indebted to Brandt for very complete contributions on the sympathetic system of the Decapoda; see his Remark über d. Mundmagen-oder Eingeweideerven der Eidechse, loc. cit. p. 7, Tab. I. fig. 1-3 (Astacus and Squilla), (also in the Ann. d. Sc. Nat. V. 1530, p. 57, Pl. XV. and in the Medit. Zool. II. Tab. XI. fig. 1, 3); see also, Krohn, Isis, 1534, p. 539, Taf. XII. fig. 1-4, and Schlemm, De hepatico ac bile Crustaceorum et Mol- luscorum, loc. cit. p. 16, Tab. I. fig. 2, Tab. II. fig. 5 (Astacus fluvitalis). Suchow (loc. cit. p. 82, Tab. XI. fig. 7, etc.) in the Crawfish, and Newport (Philos. Trans. 1854, Pl. XVII. fig. 40, l.) in the lobster, have observed only a single splanchnic nerve, which they have regarded as a cardiac nerve. Audouin and Milne Edwards, on the other hand, have described and figured with both the Macrura and the Bra- chyura, double splanchnic nerves, but the single one was entirely overlooked.

\(^{(1)}\) Brandt, Remark. &c. p. 14, and Medit. Zool. II. p. 75, Tab. XV. fig. 27, c.

\[^{[\S 272, note 35.]}\] Subsequent researches have shown that with some at least of the Cirripedia, there is a proper brain furnishing nerves to the organs of sense; see Darwin, Monogr. of the sub-

class Cirripedia, &c., p. 48 (Lepas). Even in the description referred to above, of Olton, by Wyman in Silliman's Jour., a brain is really spoken of. — Ed.
The single stomato-gastric system consists of two short trunks which extend from the brain in front, send several small filaments to the parts of the mouth, and finally pass in front of the brain, — ending in a small ganglion. From this last, arises a single nerve, which passes under the brain and extends along the oesophagus to the stomach, being, in its course, sometimes enlarged like a ganglion. The double splanchnic system, on the other hand, is composed of a double row of ganglia accompanying the oesophagus, and connected, partly by the posterior border of the brain and the single nerve, and partly by nervous branches. The filaments given off from these ganglia are distributed not only to the oesophagus, but also to the salivary glands.\(^3\)

In the genus Limulus, there is observed, as a single splanchnic nerve, only one nerve, having a ganglion and situated on the heart;\(^4\) while, with Apus, the splanchnic nervous system is highly developed. The two oesophageal commissures furnish, as with the Decapoda, two nerves which, shortly after their origin, are connected by a transverse commissure. On the oesophagus, they are blended into a single nerve, and send to this canal numerous filaments.\(^5\) With the other inferior Crustacea, no splanchnic nerves have as yet been observed.

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\section*{CHAPTER IV.}

\section*{Organs of Sense.}

\section*{§ 274.}

The sense of Touch is highly developed with Crustacea. Its seat is in the multi-articulate antennae, situated on the head, or cephalic extremity, which always contain large nerves arising directly from the brain. Often, the masticatory organs have one or several pairs of tactile appendages; and, not unfrequently, several pairs of the feet neighboring the mouth, are changed into tentacular, tactile organs, which play an important part in the choice and prehension of food.\(^6\)

\section*{§ 275.}

As Olfactory organs, with the Crustacea, may undoubtedly be regarded the two shallow excavations which, with the Macrura, and with Pagurus, are situated in the basal joint of the two median antennae. Each of these cavities communicates, externally, by a fissure-like opening, placed on the upper surface of the joint, and usually fringed with fine bristles. Inter-

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\(^3\) Brandt, Bemerk. &c. p. 34, Taf. III. fig. 6-9, and in Müller's Arch. 1837, Taf. XII. fig. 7 (Scolopendra, Syruberis, and Glomeris); also Newport, Philos. Trans. 1843, p. 246, Pl. XI. fig. 1, 2 (Julus). \(^4\) Zaddach, loc. cit. p. 36, Tab. III. fig. 5. \(^5\) The various differences of form of these tactile organs belong rather to Zoology.
nally, these organs are lined by a soft membrane, which contains a nerve arising from the brain in common with the internal antennal nerve.\(^6\)

\[\text{§ 276.}\]

Organs of Hearing, with the Crustacea, have as yet been observed only with the Decapoda.\(^6\) With these Crustacea, there is a hollow conical process, perforated at its obtuse apex, on the lower surface of the basal joint of the external antennae. Its opening is always closed by a kind of tympanitic membrane, in the centre of which there is usually a fissure.\(^3\) Behind this conical process, and in the cephalothorax, there is a large, thin-walled sac, filled with a clear liquid; this is prolonged by a kind of neck into the process, and has, undoubtedly, the function of a \textit{Labyrinthus},\(^3\) for, a special nerve, arising from the lateral parts of the brain, in common with the external antennal nerve, is spread upon its walls.\(^4\)

The base of this labyrinth is in connection with a singular glandular organ, of a usually greenish color, but whose nature is yet undetermined.\(^5\)

1 These auditory organs were first described and considered as such by \textit{Kossmadel (Reu. Arch. X. 1811, p. 433, Taf. VIII. fig. 1-4)} with the cran-fish and lobster. \textit{Trematoma} \textit{(Badege, VI. 1822, p. 205)} has subsequently confirmed these observations with the lobster. See for this same animal, \textit{Milne Edwards, Hist. Nat. d. Crust. PI. XII. fig. I.} These organs have been found lately, also, by \textit{Farre, with Palaemon and Pagurus,} (Philos. Trans. 1843, p. 233, PI. IX. X. and Ann. of Nat. Hist. XII. p. 229). I have myself observed them \textit{Palaemon, Nephrops, and Maia.} It is difficult to understand how \textit{Farre} could have taken these cavities for organs of hearing into which grains of sand, entering by accidents, would serve as ototubes.

2 Although special auditory organs have not yet been observed with the other Crustacea, yet it cannot be denied that they are sensible to sounds. At least, the observations of \textit{Coldstream (Cyclop. of Anim. I. p. 688)} show that the Crillipes have a very acute sense of hearing, for they appear cognizant of the slightest sound, and quickly close the shell.

3 This cylindric protuberance, with its tympanic membrane, is easily seen in the basilararticle mentioned, with \textit{Homarus, Antocas, Niphrops,} \textit{Palaemon, and other Nuciperida; — see Scarpia, Ammon. disquis. de audition et effectu. p. 2, Tab. IX. fig. 3, a, b;} \textit{Fesper, De aure animal. amphib. p. 3, 106, Tab. I. fig. 1, No. 1, and Milne Edwards, Hist. Nat. d. Crust. PI. XII. fig. 11, o, (Antocas).} This protuberance is long and cylindric with \textit{Pugnus striatus,} and \textit{Homona Cuscuter.}

With the Milnum, whose antennal articles are large and immovable, the auditory organs are slightly protuberant, and situated near the mouth. See \textit{Sawpyen, Descrip. de l'Egypte,} loc. cit. PI. VI. fig. 4, and 6. e. e. \textit{(Maia and Stenchchya. are,} \textit{and Milne Edwards, loc. cit. p. 288, PI. III. fig. 2, e, PL. XVI. fig. 2, 10 16, (Maia, Milne-Rax, Leucippa, and Conoipacica).}

With \textit{Scyllogus (Maia), whose antennae are very large and fixed at their base, the large flat auditory cylinders are very short and near together on the borders of the mouth. (Sawpyen loc. cit. PI. VIII. fig. 1, a, c.). With \textit{Scyllurus aquaticus}, I

\[\text{§ 276, note 2.}\]

The organ of hearing in \textit{Lenczer first noticed by Sauter;} since been studied by \textit{Haxley (Ann. of Nat. Hist. 1851, p. 301)} who appears to have clearly made out the structure which resembles the ordinary form of have found the same concealed in the semicircular depressions which are underneath the mouth. With \textit{Maia}, these cylinders are obliquely truncated, and are articulated with the large and basilar articles of the antennae. They can be depressed towards the inner side, and then righted as a kind of external auditory canal, and for this purpose the internal recess of the cylinder has a pair of muscles which are inserted on an internal, stirrup-like process; see \textit{Caulinat, Abhandl. über die Erzeugung d. Fische und der Krebs, p. 133, and Milne Edwards, Hist. Nat. d. Crust. I. p. 124, PI. XII. fig. 10, c. m., and fig. 11, and in Cyclop. of Anim. loc. cit. p.768, fig. 397, 398. Further researches are necessary, before the opinion of \textit{Soulejett (Frapec's neue Notiz XXXVII. p. 84) can be admitted, that a small, round, guttering body, with \textit{Leuciger,} is situated at the base of the internal antennae, is an auditory organ.\(^a\)

3 Formerly, the attention had been called only to the portion of this labyrinth which is concealed in the auditory cylinder (\textit{Scepa, loc. cit. Tab. IV. fig. 5, and \textit{Weber, loc. cit. Tab. I. fig. 2).} It is only lately that it has been shown that this small auditory vesicle belongs to a very large appendix situated at its base; see \textit{Brandt, Mediz. Zeit. 1843, p. 64, Tab. XI. fig. 15, a. a., and \textit{Neumayer, Anatom. Untersuch. über den Flusskrebs, in der Verh. der Natur. Gesells., bei ihrer Versamml. zu Zurich, B. H. p. 176.}

4 \textit{Scarpia, loc. cit. Tab. IV. fig. 5, a, g, g.} and \textit{Weber, loc. cit. Tab. I. fig. 2; No. 7;} \textit{Brandt,} and \textit{Neumayer, loc. cit. \& \textit{Farre,} Philos. Trans. 1843, PI. IX. fig. 10, c. c.}

5 This glandular body which appears to be present with the Brachyura also, is situated, with the Astacina, behind the base of the external antennae, concealed in the lower portion of the shell, and covered, in part, by the membranous labyrinth; see \textit{Raocel, loc. cit. p. 322, Tab. XVIII. fig. 9, c.;} \textit{Roesel, loc. cit. p. 55, Tab. IX. fig. 5, b;} \textit{Brandt, Mediz. Zeit. 1843, p. 64, Tab. XI. fig. 8, k, (Antocas), Milne Edwards, Hist. Nat. d. Crust. PI. XII. fig. 9, a. 10, p. (Antocas and Maia).} \textit{Neumayer} has given the green glands of the cran-fish a special examination (loc. cit.). He found that they consisted of an intestinal tube communicating with the membranous labyrinth. At first he auxiliary apparatus in the Mollusca. See also \textit{Schneider (Wiegmann's Arch. 1846, p. 507) upon this organ with \textit{Acanthocereus richardi;} finally, \textit{Darwin, loc. cit. Ciclopida, p. 55. — Ed.}
The sense of Sight is present quite universally with Crustacea.\(^1\) The Cirripedia, the Penellina, and the Lernaeodae, alone, are without it; and even here this deficiency occurs only during the last phases of their retrograde metamorphosis, when these animals remain fixed to foreign bodies.\(^2\) There is, moreover, in the other orders, here and there a genus which contains blind individuals. Such is the case with the females of certain parasitic Isopoda,\(^3\) and with some subterranean Myriapoda.\(^4\)

The eyes of Crustacea present very various grades of development. The lowest of these is seen in the so-called Simple-eyes. With these, there is observed a convex cornea, and, behind it, a round, light-refracting body. This lens is surrounded by a layer of black, brown, red, or blue pigment, which, at its most convex point, is perforated by an optic nerve. The young individuals of the Cirripedia, the Penellina, and the Lernaeodae, have an eye of this kind in the middle of their forehead, but which gradually disappears in the course of their metamorphosis.\(^5\) Certain Ergasilina, as likewise the Lophyropoda and Phyllopoda, have, also, at their escape from the egg, a simple eye, which, with the Ergasilina, and certain Lophyropoda,

thought them comparable to a cockscomb, but, he was unable to find any nerve going to them, and has relinquished this idea.—doubting that these organs, and the ampulla mentioned, are really auditory organs. Farre (loc. cit.) has gone further; he has taken these bodies for olfactory organs, and has endeavored to show, as already mentioned, the organs of smell to be real organs of hearing. It is true that, in the organs of hearing, no otolites are found; but the principal parts exist, such as a Cuming tympani, at the entrance of which is extend- ed a tympanitic membrane and an auditory vesicle, upon which is spread a nerve.

The view of Frey (loc. Mydals Annot. p. 13), then, is inadmissible; he regards the seat of hearing, with Mysis, as the two internal caudal valves, where he has observed a cavity containing a radiated body, the nucleus of which has a crystalline structure, and which he regards as an oticle. But, aside from the singular structure of this body, he does not mention its having any special nerves.

It is, moreover, unnecessary to seek, with those Crustacea whose antennae are highly developed, the auditory organs anywhere but on the head; for, at the base of these antennae, as, for example, with the Amphipoda, there are several other hollow processes which, in part, have been regarded as palpi, but which, upon more careful examination, will undoubtedly be found to be some auditory, and others olfactory organs.

Frey and Leuckart (Beitr. p. 114, Tab. II. fig. 19) have, from the first, described in more detail the organs of the caudal valves of Mysis, as proper auditory organs; but, aside from the two so-called otolites which, contrary to all analogy, are provided with stiff bristles, the correctness of this interpretation is always open to question, for these authors have been unable to perceive any nerve destined for these so-called auditory capsules, with Mysis.


2 The adult Cirripedia, notwithstanding the absence of eyes, are very sensitive to light. This I have observed with individuals of Balanus punctulatus, which I had captive several weeks at Danzig. These animals, when undisturbed, came out of their shell, and executed the usual motions of their cirri, but they withdrew as quick as lightning into the shell, when, from passing my hand over the vessel, I shaded them. Coldstream (Cyclop. loc. cit. p. 688) has made similar observations.*

The females of Jone, Phylacea, and Bopyrus.

4 For example, with Polydeexmus, Blainulans, Cryptots, and Geophilus.

5 For example with Achtheres, Trachaelistes, Lernaeocera (Nordmann, loc. cit. p. 80, &c., Tab. IV. fig. 5, Tab. VI. fig. 5, 6). The Cirripedia have, at their escape from the egg, a single, black eye, according to Thompson; see the Philos. Trans. 1825, p. 355, Owen, Lectures, &c., p. 161, fig. 88; and Goodair, Edinb. new Philos. Jour. 1843, No. 63, p. 97. PI. III. fig. 8, and PI. IV. fig. 12-17 (Lepas and Balanus), but with the embryos of Balanus punctulatus, I have found this eye of a red color. The reason why Burmeister (Beitr. &c. p. 19, Tab. I. fig. 2) could perceive no eye with the young of Lepas, is, as he himself has remarked, because they had been effaced by the alcohol in which the specimens examined had long been preserved.

\* [§ 277, note 2] Recent investigations have disclosed the existence of eyes with the Cirripedia. Leidy (Proceed. Acad. Sc. Phil. IV. 1848, No. 1) discovered them with Balanus, and this discovery led to the confident and successful search of them in other genera. With Lepas, according to Darwin (Monograph, &c., loc. cit. p. 49), there are two closely-approximated eyes, forming a double eye, situated at the extremity of two optic nerves which proceed each from an ophthalmic ganglion. These ganglia are situated on two nervous cords which arise from the supra esophageal ganglion. — Ed.

\[1\] § 277, note 3.] Quite remarkable among the blind Crustacea is the Astacus pellucidus Telk. from the Mammoth Cave, Kentucky. — Ed.
remains as a visual organ during the whole life; with other Lophyropoda, and with the Phyllopoda, it either entirely disappears, or remains in a condition apparently rudimentary, by the side of the other eyes, which are subsequently formed. With certain Ergasilina, and some Lophyropoda, with the Caligina, and the males of some parasitic Isopoda, there are two permanent eyes, right and left, on the vertex of the head. The Poecilopoda, also, have, beside their compound eyes, two simple ones, contiguous on the middle of the forehead. These simple eyes are also sometimes the more numerous, and are then situated on each side of the head, in fours, sixes or eights, in a single or double row, constituting the Oculi seriati, as is observed with some Myriapoda; or they are collected in a thick group of twenty to forty, constituting the Oculi gregati, as is the case with other Myriapoda, and with the Isopoda. Each of these eyes has a separate branch of the optic nerve; this nerve, therefore, divides as many times as there are eyes.

Another form of eyes which is pretty common among Crustacea, but which has many modifications, has received the name of Compound Unfaceted Eyes.

These organs are composed of a common cornea, covering numerous simple eyes, closely set against each other. They are found in their simplest form, with the Cirripedia at a certain epoch of development, with the Argulina, the Laemedipoda, and certain Lophyropoda, Phyllopoda and Amphipoda. Here, directly under the cornea, are a greater or less

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6 Lamproptera, Ergasilus (Northmann, loc. cir. Tab. II. fig. 1, 7), Cyclops, Cycloptopena, Cypris, &c.
7 With Limanda, and Isaura, it is replaced by a compound eye; see Joly, Ann. d. Sc. Nat. XVII. Pl. IX. fig. 30-41.
8 This is so with the adult individuals of Apus and the Branchiopoda, where the simple embryonic eye persists in an atrophied condition between the two faceted eyes; see Schaffer, Der krebsartige Kieferfuß, Tab. II. fig. 1 e., and Tab. V. fig. 3-5; also, Zadach, loc. cir. p. 48, Tab. II. fig. 18-22; C. and Tab. IV. (Apus); Prevost, in Jurine's Hist. d. Monoces, Pl. XX.-XXI. (Chirocephalus), and Joly, loc. cit. XIII. Pl. VII. (Artemia). The black spot observed front of the compound eye, with Lycaeus, and certain species of Daphnia, is certainly only the simple eye; see Mutter, Entomos. Tab. IX.-XI., and Jurine, Hist. d. Monoces, Pl. XV.-XVI.

But, with this simple rudimentary eye, should not be confounded the problematical vesiculiform organ which is found between the compound eyes of certain Phyllopoda and Lophyropoda. With Apus, this organ contains a nucleus, divided into four parts (Schaffer, loc. cir. Tab. II. fig. 1 b., or Zadach, loc. cir. p. 48, Tab. II. fig. 10. P., 25.). The vesiculiform body which, with Limanda, stretches from the inner surface of the head, behind the eye, towards the forehead (Browniart, loc. cir. p. 87, Pl. XI. fig. 6), may serve, according to Struve, to fix the animal to foreign bodies; see Mus. Senckenb. H. p. 120, or Férussac, Bull. d. Sc. Nat. XXII. 1839, p. 333. With Eutome, there is found at the same place, behind the large eye, a circular muscle, which also, perhaps, is for the attachment of the animal.
9 Nicolai (Rothke, Nov. Act. Nat. Cur. XX. p. 102, Tab. V. fig. 1, 8, 10).
10 Horsfield, Pettidiom, &c. (Philippi, in Wiegmann's Arch. 1839, p. 126, Tab. IV. fig. 9, 13; or Milne Edwards, Hist. d. Crust. Pl. XXXVII.).
12 Parygeus and Bopyrus (Rothke, Nov. Act. Nat. Cur. XX. p. 44, Tab. I. fig. 35, in Tab. II. fig. 3, and, de Roppon et Nercide, Tab. I. fig. 2.)
13 See Von der Heuven, Recherches, &c., 23, Pl. 111. fig. 5, a, b, 6, C.
14 With Platypus, there are, on each side, six eyes, arranged in two rows. Scopontus has four, while with Glomeris, there are eight, which form a simple arcuate row on each side; see Mul- ter, in Meckel's Arch. 1829, p. 40, Tab. III. fig. 3, 4, also Kutsorga, loc. cir. p. 17, Tab. III. fig. 6, 4 (Scopontus), and Brandt, Medta. Zool. H. p. 99, Tab. X. fig. 43 (Glomeris).
15 Treiermuus, Vermisch, Schrift. H. p. 52, Tab. VII. fig. 1 (Lithohus) and Mutter, in Meckel's Arch. 1829, p. 43 (Jullus); see also Trei- ramus loc. cir. p. 1, 64, Tab. IX. fig. 2 (Parcelli), Mutter, loc. cir. p. 42, Tab. III. fig. 4, 6 (Cymo- pha), and Lereboullet, Ann. d. Sc. Nat. loc. cir. p. 101, Pl. IV. fig. 2, 2-6 (Lygdium).

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1 [277, note 8.] With Artemia and Branchiop- us, Legidae (loc. cir. Stöhr and Kolliker's Zool. H. p. 205) has found very highly-developed eyes. In structure they correspond to the compound faceted eyes described below. In regard to the pigment-spots found on the head of these animals, and regarded as of a visual character by Joly and others, this observer considers them as mere accumulations of pigment granules, having no special function whatever. This naturalist alludes, also, to the problematical body above mentioned. He did not observe it with Artemia, but it was present with Branchiopus, and larger in the larval than in the adult conditions. He hesi- tates to express an opinion as to its nature. — Ed.
number of round, pyriform, or cuneiform lenses, the pointed posterior extremity of which is surrounded by a pigment matter of usually a deep brown or black color, while the rounded anterior extremity is always widely protuberant. The optic nerve, before reaching this pigment, divides into as many branches as there are lenses.

With Argulus,\(^{16}\) Cyamus,\(^{17}\) and with the Amphipoda,\(^{18}\) there are always two considerably flattened eyes; while with Daphnia, Lyncnus, Polyphemus, Eoradne,\(^{19}\) (the Lophyropoda) and also with the young bivalve Cirripedia,\(^{20}\) there is, on the other hand, only a single ocular bulb, spheroidal, and the result of the fusion of two eyes; it receives, therefore, the two optic nerves which are separated from each other by the median line of the body. With Limnadia, and Artemia, of the Phyllopoda, this fusion is less complete, for, upon close examination, the line of separation may be seen.\(^{21}\) With many Daphniidae, this cyclopean eye has several muscles, corresponding to the recti muscles of the Vertebrata, which give the eye a movement of rotation about its centre.\(^{22}\)

With some Crustacea belonging to the orders Amphipoda, Phyllopoda, and Pocelolpoda, the compound eyes are so modified, that, beneath the cornea which is simple, there is another cornea that is faceted. Each of these facets consists of a depression, in which fits the truncated extremity of an oblong, conical lens; and the opposite extremity of this lens is surrounded by pigments, and connected with a filament of the optic nerve.\(^{23}\)

A second modification of these compound eyes is also observed with some Amphipoda and Phyllopoda. Here, the cornea is likewise double, but between the faceted one and the conical lenses, are interposed peculiar lenses of an oval form.\(^{24}\)

The third form of eyes observed with Crustacea has received the name of Compound Faceted Eyes. These are found in the genus Scutigera,\(^{25}\) and in the higher groups of Crustacea, namely: the Stomapoda, and Decapoda, with which the eyes are situated at the extremity of two peduncles, or, what is more rare, at a point below their extremity.\(^{26}\) These peduncles are movably inserted on the anterior border of the cephalothorax, and are

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\(^{16}\) Jurine, loc. cit. p. 446, Pl. XXVI. fig. 13, and Müller, in Tiedemann's Zeitschr. f. Physiol. IV. p. 97, Taf. VI. fig. 5, 6 (Argulus foliaceus).

\(^{17}\) Roussel de Fauveme, loc. cit. p. 242, Pl. VIII. fig. 5.

\(^{18}\) Müller, in Mecke's Arch. loc. cit. p. 57, Taf. III. fig. 16, 17 (Ganomurus).

\(^{19}\) The lenses are pyriform with Daphnia (Strout, loc. cit. p. 397, Pl. XXIX. fig. 6, 7), cuneiform with Polyphemus and Eoradne (Jurine, Hist. d. Moll. cit. Pl. XV. fig. 1-3, and Lavois, loc. cit. p. 148, Pl. V.).

\(^{20}\) It is very remarkable that the Cirripedia, after the disappearance of the simple eye, which, during the embryonic state, is situated on the front, acquire another, compound but equally transitory. This last is situated at the lower border of the cephalothorax, directly in front of the mouth, during the period when these animals are contained between two shells, and swim like a Cypris. It is pedunculated, and has the same structure as that of Daphnia; see Thompson, Zool. Research.

\(^{21}\) See Brongniart, loc. cit. p. 85, Pl. XIII. fig. 3, 4 (Limnadia), and Joly loc. cit. p. 309, Pl. XVII. fig. 5, Pl. XVIII. fig. 24, 26 (Ioacris). In this last-mentioned Crustacean the eyes consist of ovoid lenses.

\(^{22}\) Daphnia and Eoradne; see Jurine and Lavois, loc. cit.

\(^{23}\) This modification is found with Amphithoe, Apus, and Limnadia; see Milne Edwards, Hist. d. Crust. I. p. 116; Zodich, loc. cit. p. 48, Tab. II. fig. 18-24, and Van der Hoeven, loc. cit. p. 23, Taf. III. fig. 6, A. B.

\(^{24}\) Hyperia (Milne Edwards, Hist. d. Crust. III. p. 74, and Ann. d. Sci. Nat. XX. 1830, p. 388, and Müller, in his Arch. 1856, p. 102), and Branchipus (Hermestein, in Müller's Arch. 1853, p. 529, Tab. XIII. fig. 1-4).

The lenses of this last-mentioned Phyllopod are located in the cup-like cavities of the cornea, so that this kind of eyes which, moreover, are pedunculated, form the transition to the faceted ones.*

\(^{25}\) With some species of Oegopoda.

* [§ 277, note 16.] For the intimate structure with many details, of the eyes of Argulus, see Leg- dig (loc. cit. Siebold and Kölliker's Zeit. S. II. p. 331, Taf. XX. fig. 1); they are not immovable as Jurine has described. — En.
THE CRUSTACEA.

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usually concealed in special fossae. The tetragonal or hexagonal facets of the cornea are always very numerous; — behind each of them, is a conical, or prismatic lens, the round extremity of which is fitted into a transparent conical fossa, corresponding to a vitreous body; while the conical extremity of these bodies is received into a kind of calyx, formed by the filaments of the optic nerve. Each of these filaments, together with its calyx, is surrounded by pigment matter in a sheath-like manner.

CHAPTER V.

DIGESTIVE APPARATUS.

§ 278.

The opening of the digestive apparatus with the Crustacea is usually situated directly in front of the first pair of feet, which, as foot-jaws, grasping or prehensile organs, are used for the seizing, the tasting, and the bearing to the mouth of food. With many species, there are, as auxiliary organs for this purpose, the oar-like, the post-abdominal, and branchial feet, the movements of which not only produce currents of water necessary for respiration, but also direct towards the mouth a great quantity of nutritive matter.

The mouth is generally situated underneath and somewhat removed from the anterior border of the head. It is covered with a soft upper lip, Phyllopoda, the Lophyropoda, and the Cirripedia. These last use principally their long, posterior, cirrus-like feet, which they unroll and roll up alternately, maintaining regular currents in the water. During these movements, the three pairs of anterior and shorter feet seize, with much address, the particles of food borne against them by the current. Often the oar-like feet with the Daphniidae become dirty in this act, and are glued together by particles of food which have been ejected from the mouth. But these animals easily relieve themselves by curving in front their spiny tail and combing out the oar-like feet, which are themselves dilated and bristled.

[§ 277, end.] There is another form of eye observed by Dana (Report on Crust. loc. cit. p. 1025) with Corophium and Sapphirina, and of so remarkable a character that I quote his description: "A pair of simple eyes, consisting of an internal prolonge lens, situated at the extremity of a vermiciform mass of pigment, and of a large, oblate, lens-shaped cornea. The cornea is connected intimately with the exterior shell of the front or the under side of the head, and the two corneae are like spectacles adapted to the near sighted lenses within; their size is extraordinary, being often one-third of the greatest breadth of the body in Corophium. The lens and the cornea are often very distant from each other, being separated by a long clear space. The external surface of the cornea is spherical; but the inner is conico-spherical, or parabolic. The texture is firm, and when dissected it breaks or cute like a crystalline lens. The true lens is always protate, with a regular contour, excepting behind, where it is partly penetrated by the pigment. The pigment is slender, vermiciform, of a deep color, either red or blue, but at its anterior extremity usually lighter, and often orange or yellow." — En.
beneath which is a pair of strong upper jaws (\textit{Mandibulae}), which move laterally by means of large muscles arising from the internal surface of the cephalic and dorsal parts of the skeleton; the internal border of these jaws is hard and often denticulated. With the higher Crustacea, these mandibles have a tactile organ (\textit{Palpus}).\textsuperscript{3}\textsuperscript{a} Behind these mandibles are two pairs of lower jaws (\textit{Maxillae}), which are weaker, softer, and deficient in palpi. They are composed of several pieces, except with the Myriapoda, where they are fused into a kind of lower lip. Between the two mandibles and the first pair of maxillae, there is a soft, tongue-shaped, and sometimes bifid process, which, also, may be regarded as an under-lip.\textsuperscript{4}\textsuperscript{a}

With many of the lower Crustacea, the parts about the mouth are variously modified, whereby they lose their peculiarities as masticatory organs. Thus with the Pocilopoda, the mouth is simple, infundibuliform, and jawless,—the mandibles and maxillae being changed into cheliform legs.\textsuperscript{5}

With the parasitic Crustacea, the organs of the mouth are changed into parts for Suction. The two lips are prolonged into a kind of proboscis, and the masticatory organs become more and more indistinct and finally disappear entirely. This is best observed with the Caligina where the mouth has the form of a beak pointing backwards, and the upper and lower lips are joined together forming a long tube which contains the two very long, horny, denticulated mandibles, while at its base are two palpiform, rudimentary maxillae.\textsuperscript{6}

With \textit{Argulus}, the oral parts form a suctorial apparatus even more complete. This is a very long proboscis, pointing forwards, and out of which the two mandibles project in the form of two small pointed stylets, while the maxillae are entirely wanting.\textsuperscript{7}

With the Lernaeaidea, and Penellina, on the other hand, the proboscis is short, and contains two short mandibles, which are denticulated and hooked; and on its outside are two palpiform, rudimentary maxillae.\textsuperscript{8} But the oral parts are most abortive with the Ergasilina and Bopyrina. Here, the upper and under lips are blended together into a short proboscis without mandibles.

\textsuperscript{3} With the Decapoda, Stomatopoda, Amphipoda, and the majority of Isopoda. With the Chilopoda, these palpi exist only in a very rudimentary condition; and they are entirely wanting with \textit{Idotea}, the Chietyra, and the lower Crustacea. For the parts of the mouth of Crustacea, see the descriptions and figures contained in the works of Savigny, \textit{Milne Edwards}, and \textit{Erichson}; also the various monographic works upon the Decapoda, Isopoda, Myriapoda, Phyllipoda, Lophyropoda, and Cirripedia, by \textit{Suckow}, \textit{Brandt}, \textit{Rahkké}, \textit{Tresramus}, \textit{Zaddach}, \textit{Jurine}, \textit{Lecin}, \textit{Barnes}, \textit{Martin St. Ange}, \&c.

\textsuperscript{4} \textit{Astacus}, \textit{Palaemon}, \textit{Palinurus}, \textit{Squilla}.

\textsuperscript{5} See \textit{Van der Hoeven}, loc. cit. p. 16, Pl. II. fig. 1 A. (\textit{Limulus}).


\textsuperscript{7} \textit{Jurine}, loc. cit. p. 440, Pl. XXVI. fig. 23-7, 16; \textit{Vogt}, loc. cit. p. 7, fig. 5.

\textsuperscript{8} Nordmann, Microgr. Beitr. loc. cit. Tab. V.—IX., and \textit{Koller}, loc. cit. Tab. IX. X. (\textit{Aetheeres}, \textit{Brachycla}, \textit{Chondracanthus}, \textit{Trachelines}, and \textit{Barnes}); also \textit{Barnes}, loc. cit. p. 310, Tab. XXIV. A. (Lernaeocera).
and the paliform maxillae, with only a few exceptions, are wholly wanting.\(^9\)

\[\text{§ 279.}\]

The Intestinal Canal with nearly all the Crustacea, traverses the body without convolutions on the median line,\(^1\) and the anus is situated at the extremity of the tail.\(^2\) Its walls are composed of three to four different layers, of which the outer, answering to a peritoneal envelope, consists of a dense fibrous membrane.

The internal layer consists of a structureless, transparent epithelium, always non-ciliated. In the anterior portion of the intestine, which is often dilated into a kind of stomach, as also in the rectum, this epithelium is quite dense and is directly continuous with the external skin, and like it also, contains chitin; it is moreover, cast off, at the moult, with the skin to which it remains attached, partly by the mouth, and partly by the anus.\(^3\) Between this epithelium and the peritoneal envelope, there is a granulo-vesicular, mucous layer, surrounded by smooth, simple, and interlaced, muscular fibres.

With the higher Crustacea, alone, the digestive canal consists always of a very short oesophagus, a stomach, an intestine and rectum. With the lower Crustacea, it is only a simple tube of the same calibre throughout, except near the anus where it is sometimes constricted by the accession of a muscular layer. With the Siphonostoma,\(^4\) and many of the Lophyro-poda and Phyllopora, it is straight throughout;\(^5\) but with the Daph-

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9 Nordmann, loc. cit. Taf. I.-III. (Lampropelma and Ergasilus); Rathke, De Bogyro &c. p. 4, Tab. I. and Nov. Act. Nat. Cur. XX. p. 42, 1863, Tab. II. V. (Nitassas and Phrygus); also Kroger, Isis, 1841, p. 343, Taf. V. fig. 7. c. (Notothoe). There is an exception in this respect, with Dicteletia, its proboscis is prolonged into a kind of beak surrounded by numerous movable processes, of which one pair of dentilicate styles concealed in a fold of the proboscis corresponds perhaps to mandibles, while another pair may perhaps be regarded as maxillici; see Rathke Nov. Act. Nat. Cur. XIX. p. 136, Tab. XVII. fig. 12-14, and Milne Edwards, Hist. d. Crust. Pl. XXXIX. fig. 4, a-c, or Cyclop. of Annt. loc. cit. p. 773, fig. 412-415.

1 Clionemis and Lynceus form here an exception. With the first, the intestine has one curve in front and another behind (Brandt, in Muller's Arch. 1837, p. 322, Taf. XII. fig. 2) with Lynceus, it has one or two spiral turns (Muller, Entomostr. Tab. IX. X. and Jurinæ, Hist. d. Monesèes Pl. XV.-XVII.).

2 The Cirripedia form an exception to this rule; their anus is situated between the last pair of cirri and the base of the tail; see Cuvier, Néron. loc. cit. fig. 7, k, and Martin St. Ange, loc. cit. Pl. II. fig. 4, 3, &c., h.


4 For the straight intestine of the Penellides, Lernocira, and Ergasilus, see Nordmann, loc. cit. Taf. I.-XII., also Burnie, Tier. Act. Nat. Cur. XVII. p. 311, Tab. XXIV. A. fig. 1. (Lernocera); Rathke, Ibid. XIX. p. 156, Tab. XVII. fig. 2 (Dichetia); Jurine Hist. d. Monesèes Pl. L.-VII. (Cyrtaceus et Cyclopinae); Prevost, Ibid. Pl. XX.-XVII. (Chirophillus); Joly, loc. cit. Pl. VII. VIII. (Articella).

5 {§ 279.} The alimentary canal of the Caligidae, according to Dana (Report. Crust. loc. cit. p. 1337), is divided into four very distinct parts,—an oesophagus, small and slender; a stomach broad and heart-shaped; an intestine, marked by light constrictions, and a rectum provided with powerful muscles. The oesophagus has a valve at its entrance into the stomach, and thereby regeneration of the food is prevented.

See also, for the digestive canal of Argulus, with its histology, Leydig (loc. cit. Siebold and Kûltler's Zeitsch. II. p. 332, Taf. XIX. fig. 2).—Eu.

6 {§ 279, note 4.} For details upon the structure of the digestive canal of Artemia and Branchipus, see Leydig (loc. cit. Siebold and Kûltler's Zeitsch. III. p. 285). This observer divides it into three distinct portions; 1. Oesophagus, Stomach, and Intestine. The stomach is composed histologically of four tunics; 1. A Muscular, made up of circular and longitudinal muscles; 2. A Homogeneous, serving as a support for this organ; 3. A Cellular; and lastly 4. A Homogeneous, which appears to be merely a continuation in words of the external Cuticle layer. The intimate structure of the intestine is quite the same as that of the stomach, but the elementary particles of the muscles composing its muscular tunic, are spindle-shaped, giving this tissue here a structure quite peculiar, and unlike anything found elsewhere; see loc. cit. Taf. VIII. fig. 6, 10.—Eu.
nioidae, and Apodidae, on the contrary, its anterior extremity mounts towards the dorsal surface of the head, and then curves backwards to the mouth.  

With the other Crustacea, there is, more or less distant from the œsophagus, a stomach, formed by a pyloric constriction of the intestine. This stomach is small with the Cirripedia, Laemodiopoda, Isopoda, and Amphipoda;  

but is pretty long with the Myriapoda.  

In many of the Isopoda and Laemodiopoda, the stomachic epithelium has stiff cilia, or presents a cartilaginous, or horny aspect, thus constituting a stomachic support and dental apparatus, which is also observed in the somewhat larger stomach of the Pociliopoda and Stomatopoda.  

But this structure of the stomach is most prominent with the Decapoda. Remarkable for its size and form, it consists of two portions; one, anterior, vesiculiform, communicating with the œsophagus, the other pyloric, pyramidal, and with the apex pointing backwards. The internal lining of the stomach is composed of chitine and covered with stiff bristles, or sometimes with groups of very singular hairs of a forniculate form. Moreover, its callous and cartilaginous portions form, in the pyloric region, a remarkable support, on which are three solid movable pieces. One of these pieces is a single tooth placed in the middle of the posterior wall of the stomach; while the other two, longer and somewhat crenulated, are situated on the sides opposite each other. Several muscles, arising from the internal surface of the ephalothorax, are inserted on this stomach, and it is very probable that, by these, the animal can voluntarily bring the three pieces together, making them serve as internal masticatory organs.

5 For the arcuate intestine of Daphnia, Lycus, and Polyphemus, see the figures given by Jurine, Hist. d. Monocel.; Straus, loc. cit. Pl. XIX. (Daphnia); Bronnwart, loc. cit. Pl. XII. (Limnadia); Straus, Mus. Seocneb. loc. cit. p. 112, Taf. VII. fig. 12, and Joly, loc. cit. Pl. VII. fig. 5 (Isosura). With Erypites there is a kind of stomach on the curved digestive canal (Straus, loc. cit. p. 90, Pl. I, fig. 10).  

6 For the intestine and stomach of the Cirripedia, see the writings of Guericke, Bianmeister, and Martin St. Ange; also Roussel de Vauzeme, loc. cit. Pl. VIII. fig. 12, 18 (Cyanus); Brantde, Mediz. Zool. II. Tab. XV. fig. 20 (Oyhnus): Lerbe-

boulet, loc. cit. p. 136, Pl. V. fig. 25 (Lycidea), and Ratke, loc. cit. Taf. IV. fig. 10 (Idothes).  

7 See Rambauer, Abhandl. d. d. Veroulaugsr. d. Æst. p. 143, Taf. XV. fig. 1; Trentras, Vern. Schrif. II. p. 23, 45, Taf. V. fig. 4, Taf. VIII. fig. 6 (Lithobius and Julus); L. Dufour, loc. cit. p. 14, 15, Pl. V. fig. 1, 4 (Lithobius and Scutigera); Kutorga, loc. cit. p. 3, Tab. I. fig. 2 (Scopelopodra) and Brantde, in Muller's Arch. loc. cit. Taf. XII. fig. 2 (Gomorri).  

8 The stomach of Oynesus contains a cartilaginous support of a peculiar form (Brantde, Mediz. Zool. II. p. 74, Taf. XV. fig. 41, 42). That of the stomach of /Idothes entomon/ is composed of several solid pieces (Ratke, loc. cit. p. 119, Taf. IV. fig. 20, 21). With Lycidea, the epithelium is supported by several horny pieces, and provided with numerous stiff bristles (Lerbe-

boulet, loc. cit. p. 127, Pl. V. fig. 26-30). Finally, with Cyanus, there are in the cardiac region of the stomach two lateral hornv tridentate folds (Roussel de Vauzeme, loc. cit. p. 251, Pl. VIII. fig. 13, 14).  

9 With Limnulus, the œsophagus extends in front and opens into a very muscular backwardly-curved stomach the epithelium of which has fifteen longitudinal rows of horny teeth ('Van der Hooven, loc. cit. p. 17, Pl. II. fig. 3, b.); With Solei/da, the stomach is pyramidal, and has, at its pyloric region, horny plates and very regular rows of hairs (Jucervany, in Carter's Leges d'Amor. Comp. V. p. 231). With Mysies, also, the epithelium of the pyriform stomach is supported by several solid lamellæ composed of chitine and covered with bristles mixed with hairs (Preg, loc. cit. p. 16).  

10 The stomach of the Crawfish is the one best known; see the descriptions and figures given by Roesel, Suckow, Brandt, loc. cit., and Milne Edwards, Hist. d. Crust. I. p. 67, Pl. IV. The intimate structure of this stomach and its internal appendages have been carefully studied by Valen-

tin (Repertoriana, I. p. 115, Taf. I. fig. 13-21) and by Oesterlen (Muller's Arch. 1840, p. 387, Taf. XIII). The teeth and bristles here observed, are found also with the three divisions of the Decapoda. I have seen them with Homarus, Palamn, Galba-

thea, Pardurus, Cancer, Masu, Lypae, &c. With Crangon, and Palaemon, I found the dental lamellæ wanting but the epithelium was hairy. With Caridina, according to Joly (loc. cit. p. 84, Pl. III. fig. 27), hairs of this kind are inserted on the hand-like condensations of the stomach.

Fauna within Living Animals, in Smithsonian Contributions to Knowledge, V. 1853. — Ed.
A large portion of the Crustacea have glandular appendages to the digestive canal. But it is only a few of these organs to which can be attributed the function of Salivary Glands. Two such of a lobular form, are found in the Cirripedia on the stomach, and pour their secretion into the anterior part of this organ.\(^1\)

But with the Myriapoda, these organs are very distinct. There are two or more on each side of the esophagus and stomach, and their rather long, excretory ducts open into the oral cavity.\(^2\) With all the other Crustacea, these organs are wholly wanting.\(^3\)

The Liver, which exists sometimes as a glandular layer enveloping the digestive canal, and sometimes as a separate organ, is composed of greenish, or of yellowish-brown tubes of variable size, the walls of which are formed by numerous granular cells, between which are interposed fat-vesticles.\(^4\)

With most of the lower Crustacea, with the Siphonostoma, the Lophyropoda, the Phyllopoda, and Myriapoda, the liver is not isolated from the digestive tube, but the follicles of its glandular layer are somewhat protuberant on the external surface of this tube, and open on its internal surface, each probably by a separate orifice.\(^5\)

With _Argulus_, the salivary organs are even longer and larger, with the urinary canals, a very complicated network about the stomach, and from which pass off, according to _Treviranus_ (loc. cit. p. 44, Tab. VIII. fig. 5), three excretory ducts to the mouth. But _Rambur_ (Abhandl., &c. p. 109, Tab. XV. fig. 1, g, g) has figured only two simple salivary canals with _Julus_, and this number has been verified by _Barmsteiner_ (Ibis, 1854, p. 196). I have seen these two canals with _Julus sabulosus_ Anastomose in an areate manner at the posterior extremity.\(^6\)

For the intimate structure of the biliary tubes, see _Schlemmer_, _De hepatis ac bilic Crust._, loc. cit. p. 14, Tab. II. fig. 1-5 (Abtascus), and _Kursten_, _Nov. Act. Nat. Cur. XVI_. p. 259, Tab. XVIII. -XX. (Ouuseus, Astacus, and _Balanus_).

An hepatic layer of this kind may be observed with the _Punella_, _Lernaces_, _Euryallus_ (Nordmann, loc. cit. Taf. 1-3), and with _Artemia_ (Joly, loc. cit. p. 259, Tab. VIII. fig. 4). The numerous circe, which, according to _Rathke_ (Nov. Act. Nat. Cur. XX. p. 122, Tab. V. fig. 10), belong to the entire digestive canal of _Chondracanthus_, are perhaps formed by an hepatic substance. With the _Clitumnus_ and _Chilopoda_, I have found the

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1 See _Cuvier_, Mem. loc. cit. p. 10, fig. 9, u., u., fig. 13. (Lepus); _Helmhitter_, loc. cit. p. 42, Tab. II. fig. 43, 14, a. (Diuraphis); _Kursten_, Nov. Act. Nat. Cur. XXI. Tab. XX. fig. 1, d. (Batanus).
2 With _Lithobius_ and _Souticera_, there are two compact salivary glands which extend from the head into the first segments of the body (L. _Dufour_, loc. cit. p. 83, 95, Pl. I. V.). _Treviranus_ (Verm. Schrith. H. p. 29, Tab. V. fig. 4, 9, 5.) regarded them as a mass of fat. The botryoidal glands, which open by several excretory ducts into the oral cavity, have been observed by _Garde_ (Wiedemann's med. Mag. I. p. 107, Taf. I. fig. 7, i.), by _Muller_ (Ibis, 1829, Taf. II. fig. 5), and by _Kurtz_ (loc. cit. p. 4, Tab. I. fig. 4), in the anterior extremity of the body of _Scopionepeta_. With _Glomeria_, there are only two short, slightly flexuous glandular tubes situated in the lower portion of the head and opening into the mouth (Brandt, in Muller's Arch. 1857, p. 523, Tab. XII. fig. 5). With other Myriapoda, these organs quite resemble those of the Insecta. Thus, with _Graphilus_, there are two flexuous tubes situated pretty far behind the head, and from which pass off very long, small excretory ducts along the esophagus to the mouth (Treviranus, loc. cit. p. 37, Tab. VII. fig. 3).

3 With _Julus_, the salivary organs are even longer and larger, with the urinary canals, a very complicated network about the stomach, and from which pass off, according to _Treviranus_ (loc. cit. p. 44, Tab. VIII. fig. 5), three excretory ducts to the mouth. But _Rambur_ (Abhandl., &c. p. 109, Tab. XV. fig. 1, g, g) has figured only two simple salivary canals with _Julus_, and this number has been verified by _Barmsteiner_ (Ibis, 1854, p. 196). I have seen these two canals with _Julus sabulosus_ Anastomose in an areate manner at the posterior extremity.\(^6\)

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Daphnia, and Aipus, alone, the anterior extremity of the intestinal canal has several single or ramose caeca, the walls of which appear to serve principally as hepatic organs. (6) With the Cirripedia, similar caeca exist on the stomach, (6) and form, evidently, the transition to the hepatic organs of the other Crustacea,—that is, to an isolated liver with special, though short excretory canals. Such an isolated liver occurs with the Laemodipoda, Iso- poda, and Amphipoda, and consists of long varicose caeca arising from the base of the stomach, and accompanying the intestine a considerable distance. (7)

With the Pocillipoda, Stomatopoda, and Bopyrina, the hepatic organs are inserted at various points along the digestive canal. (8) Finally, with the Decapoda, the liver consists of two glandular masses composed of more or less ramose caeca loosely bound together. Each of these glands, which sometimes occupies only the sides of the cephalothorax, but sometimes, also, largest portion of the alimentary canal dotted with small, yellowish-brown follicles, which I can only regard as hepatic organs, although other Zoologist consider them as Malphigian canals (see § 287). L. Dufour (loc. cit. p. 96, Pl. v. fig. 4, R.) has found these follicles in the stomach of Scutigerä, but did not regard them as hepatic. The numerous large cells, which, according to Heres (Ann. du Mus. d'Hist. Nat. XX. p. 290), cover the external tunics of the intestine of Litho- bius, are certainly only follicles of this kind. (5)

With Daphnia, there are two lateral, backwardly-curved caeca, which ascend from the anterior extremity of the digestive canal towards the dorsal surface of the head (see Schaffer, loc. cit. p. 41, Taf. II. fig. 2, k; k; Strons, loc. cit. p. 401, Pl. XXIX. fig. 5, s. a., and Jurine, Hist. d. Monocl. Pl. IX. X. fig. 7, XI.-XIII.). With Branchipus, and Artemia (Joly, loc. cit.), the anterior extremity of the digestive tube has also two short caeca which, with the glandular tunics with which the remainder of the intestine is covered, should be regarded as a liver. With Argulus, the stomach has two multiramose caeca, which lie in the parenchyma of the body (Jurine, loc. cit. p. 441, Pl. XXVII. fig. 1.-3, 3, or l; Arct., loc. cit. p. 8, fig. 1.9). With Aipus, these caeca are given off from the anterior extremity of the digestive canal and extend far beyond the anterior border of the cephalothorax (Schaffer, loc. cit. p. 70, Taf. V. fig. 15, a.). According to Zaddach (loc. cit. p. 8, Tab. I. fig. 10-15, and Tab. IV.), these caeca contain numerous glandular follicles. (6)

Beside the figures of these stomatous appendages in the works of Cuiter, Eremie, and Martin St. Ange, see also particularly those which Karsten (Nov. Act. Nat. Cur. XXI. p. 301, Tab. XX. fig. 1-4) has given of the hepatic organs surrounding the pylorus with Helicea. (7)

With Cymus, there are two long hepatic caeca which wind over the digestive canal (Ronn- sel de Faucon, loc. cit. p. 252, Pl. IX. fig. 10). The two stomatous appendages of Idotea which Rathke (loc. cit. p. 121) has taken for adipose bodies, belong to the hepatic apparatus which here, according to my observations (Muller's Arch. 1837, p. 438) consists of three pairs of yellow varicose tubes. With Oniscus, Porcellio, Anaxius, and Lygidaeum, there are four very long varicose hepatic tubes which open right and left into the pylorus (Treatises, Vern. Schrift. I. p. 57, Taf. V. fig. 38, Taf. XI. fig. 50, Taf. XI. fig. 64; Brandt, Mediz. Zool. II. p. 75, Taf. XV. fig. 39; Lereboullet, loc. cit. p. 150, Pl. V. fig. 25; Kars- ten, loc. cit. p. 290, Taf. XXVII. fig. 1). Treat- isanus, who did not observe the excretory ducts of these glands regarded them as masses of fat, while Rambour (Abhnnll. oh. d. Verhandlungen, loc. p. 204, Taf. XXVIII. fig. 3), who, probably by mistake, has figured with Porcellia three similar appendages, has taken them for salivary organs. There are three pairs of hepatic canals with Cymu- thoa (Meckel, Syst. d. vergle. Ann. IV. p. 194), Tres (Rathke, Nov. Act. Nat. Cur. XX. p. 50, Tab. VI. fig. 16, d. 13), and Lygia (Miles Ed- wards, Hist. Nat. d. Crust. Pl. IV. fig. 3). I cannot now decide whether Hiella has really only one varicose hepatic tube, or whether the others were overlooked by Strons (loc. cit. p. 59, Pl. IV. fig. 15). With Gymnmaus, and the other Amphipoda, I have found two pairs of long hepatic tubes. Frey and Leuckart (Beitr. p. 104) have found with Caprella, as with Cymus, two simple hepatic caeca. (8)

With Limnus, there are four groups of inter- laced caecal canals situated in both sides of the cephalothorax. The liver is poured into the ante- rior portion of the intestine by four distinct excre- tory ducts, which are widely separated from each other (Van der Hoorn, loc. cit. p. 18, Pl. II. fig. 1, 5, 8). With Squilla, Bopyrus, and Phryganea, the digestive canal has ramose or varicose hepatic caeca on both sides, at irregular intervals, of its whole length (Muller, De Giam, Brux. p. 76, Tab. IX. d. Duemay, Ann. d. Sci. Nat. VI. 1836, p. 242, Pl. XV. fig. 1 Squilla); and Rathke, De Bopyro et Nereide, p. 9, Tab. I. fig. 7, and Nov. Act. Nat. Cur. XX. p. 47, (Bopyrus and Phryg- ana). The genus Myias (Frey, loc. cit. p. 19) on the contrary, which has eight hepatic canals opening right and left into the base of the stomach, resembles again the Amphipoda and Isopoda.

by Leydig (Ueber Argulus, &c., and Ueber Ar- temis, &c., loc. cit. Siebold et Kükuller's Zeitsch. 11. p. 364, and III. p. 250) on histological grounds; it is most probable however that they serve as a liver, since Will (Muller's Arch. 1845. p. 566) has shown, by chemical analysis, the hepatic nature of analogous caecal tubes with Daphnia and Cyclops. — En.

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§ 281.

With many Crustacea, the digestive canal is surrounded with fat-cells, the contents of which are often of a beautiful orange or blue color. These cells either consist of a few scattered globules, or are disposed in lobes of various forms. This tissue is undoubtedly analogous to the Corpus adiposum, so common in insects.

The fat which these cells contain, plays a part, probably, in digestion and assimilation; for with these animals the excess of nutriment is deposited as fat to be used in times of need, as, for example, during the act of moulting. This explains why the quantity found is so variable, or even may be entirely wanting.

CHAPTER VI.

CIRCULATORY SYSTEM.

§ 282.

Although the blood of Crustacea traverses the body by a very regular circulation, yet, as with all the Arthropoda, the vascular system is here quite imperfect, the blood-currents not always being contained in proper canals. But a central, propelling organ is very rarely absent, and consists of a heart, sometimes round and vesiculiform, sometimes long and tubular. With the higher Crustacea, it is the point of departure of an arterial system which, with the lower orders, gradually becomes abortive, and at last entirely disappears. The more or less long arteries do not terminate peripherically in a capillary net-work, but the blood is freely diffused into the

9 For the liver of the common craw-fish, which is large but contained in the cephalothorax, see the descriptions and figures of Roessel, Suckow, Gevel, Brandt, and Schleumatic, also those of Mutter (De Ghand. Struct. p. 69). This last mentioned author found the liver conformable with that of many of the other Mecurus and Brachyura. Milne Edwards (Hist. d. Crust. Pl. IV. fig. 5) has found, with Malia, a hepatic mass very remarkable in being symmetrically divided into several lobes. With Pagonura, there is, on each side of the pylorus, a long biliary vessel, which extends along the intestine to the extremity of the tail, and into which numerous lateral follicles empty their product; see Swanmerdamm, loc. cit. p. 86, Taf. XI. fig. 4, 3; Mutter, De Ghand. &c. p. 70, Tab. VIII. fig. 12, 13; and Delle Chiuse, Descriz. &c. Tav. LXXXVI. fig. 6.

10 These fat-globules, of an orange color, are often found scattered about in Cyclops, Daphnia and Gammarus.

11 Such lobes and of a blue color are found with Branchipes on the sides of the digestive canal. Other whitish adipose masses form a kind of net-work around the intestinal canal of Lernaea, Lernacaecora and Lampropleura (Karthk, Nov. Act. Nat. Carr. XX. p. 228, and Nordmann, loc. cit. p. 6, 123, 124, Taf. I. fig. 4, Taf. VI. fig. 4). This last observer has regarded this reticulated mass as a liver. With the Myriopoda, these adipose masses are large, lobulated, and occupy quite a space in the visceral cavity.

* [§ 281, note 9.] For the intimate structure of the liver of Crustacea, as elucidated by the microscope, see Leidy, Amer. Jour. Med. Sc. 1848, XV. p. 1. — Eu.
lacunae which lie between the different visceral organs and appendages of the body. But, notwithstanding the absence of vascular walls in these interstices, the blood moves in determinate directions, until, after a course of variable length, it is returned to the heart. During their course, the blood-currents are often taken up by particular reservoirs, which, as venous sinuses, may be regarded as forming the rudiments of the venous system. In this manner, notwithstanding the imperfection of this vascular apparatus, all the organs constantly receive fresh blood, which is nowhere stagnant; also, the arterial may be clearly distinguished from the venous currents, even when the arterial walls are wanting.

The Blood, itself, is either colorless, or of a faint red or violet hue. These colors belong to the blood-liquid, and not to the contained globules, which are few and always colorless. These globules are round, oval, or pyriform; their surface is rough, and they contain fine granules, and, often a very large nucleus.\(^1\)

\[\text{§ 283.}\]

The Heart of the Crustacea. is always situated in the axis of the body, directly under the shell, at the anterior part of the back, and is often attached to the internal surface of the skeleton by muscular fibres. Usually, its walls are thin and composed of scattered muscular fibres interlaced in various ways. By the contraction of these fibres the blood is propelled from behind forwards through the arterial orifices, — those of the veins being closed at the same time by valves.

The number of these different orifices, and the form and divisions of the Heart, have the following modifications:

1. With many of the lower Crustacea, especially with the Siphonostoma, and the Lophophyopoda, the heart is a simple, thin-walled sac, of either a spheroidal or an elongated form, but invariably with only two orifices, — a posterior or venous, and an anterior or arterial.\(^2\)

\[\text{\textit{[§ 283, note 1.]}}\] With Calliggus, the circulation is wholly lacunal, and appears to consist of broad irregular streams, passing through the spaces left by the internal organs, — there being in no part distinct vessels. A single centre of circulation, or a heart, can scarcely be said to here exist, but there are two points in the median line where there is a valvular action, and which perhaps perform the functions of this organ; see Dana, Calligus, &c., Amer. Jour. Sc. XXXIV. p. 237, Pl. III. fig. 6, a, 6, b.

A corresponding structure has been found with Argulus, by Leidy (loc. cit. Siebold and Kolliker's Zeitsch. 11. p. 235, Taf. XIX. fig. 5), who has given, moreover, many histological details upon the circulatory system of these animals. — Eb.
2. With the other Crustacea, excepting the Myriapoda, the heart has, likewise, the form of a short simple sac, or that of a simple tube. In both cases, it is perforated by very numerous arterial and venous orifices. During the systole, the blood is propelled through the arterial orifices leading, nearly always, into vessels of the same nature; at the same time, the venous orifices are closed by valves, which open, however, during the diastole, to allow the ingress of the blood into the heart.

With the Decapoda, the heart is vesiculiform, situated in the middle of the cephalothorax, and its projecting corners often give it a star-like aspect. This heart has arteries passing off in front, behind, and below, and the returning venous blood enters it through venous orifices on its upper lateral portion. With the Pocillopoda, Isopoda, Amphipoda, and probably, also, with the Laemodipoda, and Cirripedia, the tubular heart, occupying a large portion of the anterior and middle regions of the back, sends off arteries before, behind, and laterally, and receives the venous blood through lateral venous orifices. This organ is most highly developed with the Stomatopoda, where it occupies nearly the whole length of the body like a tube; but with the Isopoda, the tubular heart is continuous with an anterior and a posterior arch: it receives only three to five pairs of lateral vessels which have been regarded sometimes as arteries and sometimes as venous; see Trescaurus, Vern. Schrift. I. p. 58, 65, Taf. VIII. fig. 46, and Taf. IX. fig. 55 (Porcellio) and Trescaurus; Brandt, Nat. Syst. II. p. 72, Taf. XV. fig. 38 (Porcellio); Lecitholobus, loc. cit. p. 131, Pl. V. fig. 33 (Lygmodium); Rothke, in the Neuest. Dampg, Schrift. I. p. 122 (thraza), and Nov. Act. Nat. Cur. XX. p. 51 (dega). It is, however, very probable that these orifices are arterial, for they open into vessels, and, moreover, the venous orifices are found, as with Limulus, on the dorsal surface of the organ. For the Amphipoda, Gammarus pulex may be cited as a type, and of which the heart as a cylindrical vessel occupies the axis of the anterior segments of the body. In this animal may be very easily seen how the blood, with the diastole, enters the heart through the several dorsal venous orifices, and how, with the systole, it is thrown forwards, backwards and laterally through the arterial openings.

We have not yet complete researches as to the heart of the Cirripedia; but since Martin St. Ange (loc. cit. p. 18) states that these animals have a dorsal vessel with lateral trunks, it may be concluded that their heart is like that of the Amphipoda, Isopoda, &c. As to the Laemodipoda, we have only the imperfect details given by Trescaurus (Vern. Schrift. II. p. 5), and Roussel de Fauvazine (loc. cit. p. 254), according to which there is, with Cypaea, only a simple tube opening before and behind; and we are therefore unable to say whether this heart is formed after the first or second type indicated in the text.

4 With Mysis, the heart consists, according to Frey (loc. cit. p. 21), of a dorsal vessel extending from the cephalothorax into the back part of the body; but the blood enters it only through a posterior Ostium venosum, and passes out into the body through an anterior Ostium arteriosum. If this organization be confirmed, Mysis will differ from this respect from the Isopoda, Amphipoda, &c., but especially from another Stomatopoda genus, Spatula; for in this last, the heart with its anterior, posterior and lateral orifices, reaches its greatest development, occupying the entire abdominal cavity except the cephalothorax, and sending off laterally to several pairs of arteries, besides being perforated on its upper portion by various pairs of venous orifices; see Dauvigny, Ann. d. Sci. Nat. VIII. 1837, p. 42, Pl. 8. 

2 There are, usually, in the polygonal heart of the Decapoda, three anterior arterial orifices, two below and one behind. These open distinctly into muscular arteries; see Steenstrup, Annal. loc. cit. p. 57, Taf. XI. fig. 8 (Pagurus); Roessel, loc. cit. p. 58, Taf. IX. fig. 14, and Suckow, loc. cit. p. 58, Taf. IX. fig. 1, Taf. XI. fig. 2 (Aestes); Audoin and Milne Edwards, Ann. d. Sci. Nat. XI. 1837, p. 555, 563, Pl. XXIV. XXVII. fig. 1; and Milne Edwards, Hist. d. Crust. Pl. V. VII. (Maia and Homarusa), and Cyclop. d'Anat. loc. cit. p. 775, fig. 418 (Concor). Not so easily seen are the six venous orifices which always are only valvular structures, chiefly because they do not open into veins. According to Lund, and A. W. F. Schultz (Isis, 1825, p. 594, Taf. III. fig. 2-4); Ibid. 1823, p. 1234, (Homarusa), and 1839, p. 1229, with the figure of p. 1228, (Maia), the heart of the macrourous Decapoda has two upper, two lower, and two lateral venous orifices, while that of the Brachyura has only four upper and two lateral. Krohn (Isis, 1834, p. 524, Taf. XII. fig. 1-3), has confirmed this observation with the crawfish. Suckow, however (loc. cit. p. 58, Taf. XI. fig. 2), a. a. a., did not perceive in this species only two upper orifices, while Audoin and Milne Edwards (Ann. d. Sci. Nat. loc. cit. p. 557, 564, Pl. XXIV. fig. 3; N. 90) have not observed in the heart of Homarusa and Maia only the two lateral orifices. This last naturalist (Hist. d. Crust. I. p. 94, Pl. VI. 1.) refuses to admit the description of the heart of the Decapoda given by Lund, and brings to his support (Cyclop. loc. cit. p. 777) Hunter's preparations of the lobster; but, judging from the beautiful figures of them given by Owen (Catal. of the Phys. Ser. II. Pl. XV. h. h. Pl. XV. fig. 2, d. d. and especially fig. 1, f. f.) these are just the preparations to support the view of Lund, Schultz, and Krohn. 1, at least, have perceived distinctly the upper, lower and lateral venous orifices, as "the three orifices of the vesicula passing into the heart, f. f. f." See also the description of Owen of the heart of the lobster in his Lectures on Comp. Anat. p. 173, fig. 91.

3 For the heart of Limulus, see Strata, Consul. gen. st Petan. comp. des mar. anim. p. 346, and especially Van der Hoeven, loc. cit. p. 18, Pl. II. fig. 9. Beside the anterior and posterior arterial orifice, there are, with these Crustacea, other orifices belonging to the seven pairs of lateral arteries, and on the dorsal portion of the organ, an equal number of valvular openings belonging to the venous system. With the
Phyllopoda, it is less elongated and has numerous constrictions, thereby resembling the following type.\(^6\)

3. This type, the third, is found with the Myriapoda, and considerably resembles that of the so-called Dorsal Vessel of the Insecta. With the Chilognatha, and Chilopoda, it consists of a more or less articulated tube, occupying the whole dorsal line of the body. It is divided by constrictions and imperfect muscular septa into chambers, nearly as numerous as the segments of the body. Each chamber is attached, as with the Insecta, right and left to the internal surface of the segments of the body, by triangular muscles. The Diastole is produced chiefly through these muscles. At its anterior extremity, this dorsal vessel passes through an Ostium arteriosum into an aorta, while, from the posterior extremity of each of these chambers are given off two lateral arteries. The returning blood enters the heart through the two venous orifices on the dorsal surface of each compartment. The Systole consists of an undulating action from behind-forwards, and the blood is thereby propelled partly from one chamber to the next forward, and partly into the lateral arteries.\(^6\)

\section*{§ 284.}

The Circulation outside of the heart, with the Crustacea, has very varied relations, as has already been mentioned. With the lower Crustacea, with the Siphonostoma, the Lophyropoda, and the Phyllopoda, the blood forms regular currents in the intervisceral lacunae and interstices, but there is no trace of vascular walls. The aortic current, shortly after leaving the heart, divides into a right and left portion, which, also, sub-divide, enter the appendages of the cephalic extremity, then turn and run along the abdominal surface of the body—furnishing, in their course, several lateral, loop-like currents, which enter the locomotive organs, then turn again towards the posterior extremity of the back, where they enter the heart.\(^5\) 

\[\text{II. fig. 1, and especially Audouin and Milne Edwards, \textit{Ibid.} XI. 1827, p. 376, Pl. XXXII. These labourious have very distinctly represented the dorsal venous orifices of the heart just mentioned.}\]

5 With Branchipus, Artemia, Isaura, and Apus, the heart which has several constrictions and whose venous orifices are very apparent, occupies the entire dorsal median line excepting in the caudal extremity; see \textit{July}, Ann. d. Sc. Nat. XIII. p. 239, Pl. VIII. fig. 4, j, XVII. p. 307, Pl. IX. fig. 43, r; also Krohn, \textit{Fröri}'s neue Not. XLIX. p. 206, fig. 1, 2; and Zschokke, loc. cit. p. 11, Tab. I. fig. 17, C, Tab. II. fig. 4-14.\(^6\)

6 Although \textit{Trestitanus} (Verm. Schrill. II. p. 31, Taf. VI. fig. 6), and \textit{Antogna} (loc. cit. p. 15) have, indeed, furnished some communications on the heart of Lithobius and Scytopendra, yet we are really indebted for what is known of the structure of this organ with the Myriapoda to the excellent researches of Newport; see Philos. Trans. XXIII. p. 272, Pl. XXII. fig. 18-22 (Scytopendra), and fig. 25 (Scutigera). According to these investigations, the interventricular septa are scarcely developed with the Chilognatha, although very much so with the Phyllopoda.

An extra vascular circulation has been observed with the Lernacea, by Nordmann (loc. cit. p. 73, 90), and with the Caligina, by Pickering and Dana (\textit{Ibis}, 1840, p. 285, 1841, Taf. IV.). Jurine (loc. cit. p. 437, Pl. XXVI. fig. 8), and, with more exactness, \textit{Faget} (loc. cit. p. 9, Taf. I. fig. 10), have described the circulation with \textit{Argulus}. For that of \textit{Daphnia}, see Gruithuisen, \textit{Nov. Act. Nat. Ger. XIV.} p. 440, Tab. XXIV. fig. 6; \textit{Perty}, \textit{Ibis}, 1832, p. 725, and Ehrenberg, \textit{Abh. d. R. Akad. Akad. 1836}, p. 189, note. \textit{Zaduck} (loc. cit. p. 23, Tab. I. fig. 17) has represented in much detail that of \textit{Apus}. In order to be convinced of the entire want of vascular walls with the lower Crustacea, there is perhaps no species which will serve better than \textit{Argulus fallacius} whose body is wholly flattened and transparent throughout.\(^6\)
With the other Crustacea, with which the heart is unarticulated, the blood passes from this organ into arterial canals; but the walls of these last sooner or later entirely disappear, so that here also the blood circulates at liberty between the interstices of the body. The regular arterial currents thus formed finally bend about and become those of the venous system. With the Isopoda, and the Amphipoda, perhaps, also, with the Pocelopoda, and Laemodipoda, the anterior, posterior, and lateral arterial trunks disappear after a very short course.(3)

With the Stomapoda, and Decapoda, the arterial system is pretty well developed, and can be traced even to its ultimate ramifications. With the first, the heart, at its anterior extremity, sends off a simple, pretty long aorta, which ramifies to the eyes and tentacles; while from its sides, pass off numerous arteries for the segments of the body and their appendages, and, posteriorly, a branch which extends to the very extremity of the tail.(3)

With the Decapoda, on the other hand, the heart has three anterior aortae, of which the middle one goes, almost unbranched, to the eyes, while the two lateral, belonging to the antennae, give off, in their course, branches to the cephalo-thoracic organs. The two hepatic organs, alone, have special arteries, which arise directly from the lower surface of the heart. Behind, there is a posterior aorta which, immediately after its origin, divides into a dorsal and an abdominal branch. The first of these, either simple as with the Macura, or bifurcated as with the Brachyura, extends even to the end of the tail, sending off branches right and left. The second passes below, and is distributed principally to the feet, the pincers, the foot-jaws, and the maxillae.(1)

2 According to the researches of Treviranus (Verm. Schrifl, I. p. 78) upon Asthen, and of Zenker (loc. cit. p. 21) upon Gammarus, the arterial system is very rudimentary with the Isopoda, and Amphipoda. This may be easily proved by an examination of allied species. It may be asked, however, if the blood-currents of these Crustacea are not enveloped in vascular walls so delicate as to escape observation; but with proper care one may be satisfied that no such walls exist. From muscular contractions or the bending of the articulations, the current of the blood is often stopped, and then the blood-globules evade the obstacle by passing at any point directly from the arterial into the venous current.

Gooden (Edinb. new Philos. Jour. July, 1842, p. 184) was certainly deceived when he affirmed that he had observed the blood of Caprella circulating in arterial and venous vessels.

The absence of vascular walls with Caprella, already observed by Wiegmann (Arch. 1839, I. p. 111), has been confirmed by Frey and Leuckart (loc. cit. p. 104, Taf. II. fig. 19, 20), and, according to them, the circulation here is analogous to that of the Amphipoda.*

3 This disposition of the arterial system has been observed by Audouin, Milne Edwards, and Dumeril (Ann. d. Sc. Nat. XI. 1827, p. 577, Pl. XXXII. and VIII. 1837, p. 33, Pl. II. fig. 1), with Spulla, while Mytilus appears from its circulatory organs to be allied to the Isopoda and Amphipoda; see Thompson, Zool. Research. loc. cit. I. p. 15, and Frey, loc. cit. p. 13.

4 The arterial system of Mata and Homarus has been described with many details in the so-oftenquoted memoir of Audouin and Milne Edwards (Ann. d. Sc. Nat. XI. 1827, p. 363, Pl. XXI-V. XXXIX.). Lund, also (Isis, 1852, p. 593, Taf. II. fig. 1), has very well described the arteries of the lobster. But especially should be noticed the excellent preparations of Hunter of the arterial system of this same animal (Catal. of the Physiol. Ser. 11. Pt. XV.-XVIII.). For this system with the crawfish, see Brandt, Med. Zool. loc. cit. p. 63, Taf. XI. fig. 2; and for that of Cancer pagurus, Milne Edwards, in the Cyclopa. loc. cit. p. 775, fig. 418.

enters this organ without passing to the branchiostegite, but the other portions traverse the gills and afterwards returns to the heart.* — En.

* [§ 284, note 2] In a private letter Agassiz has communicated some interesting facts on the circulation of Caprella. He says "Caprella has a tubular, dorsal vessel with lateral valves, exactly like the larvae of Isotta, — the blood is emptied, in front, into the main cavity of the body, moves backwards along the lower part of that cavity without being enclosed in vascular walls, and returns to the dorsal vessel through the lateral valves. The circulation was traced in a living animal into which a solution of a small quantity of carmine had been injected. — En.
§ 284. THE CRUSTACEA.

With all the Crustacea, the venous currents gradually converge from the lower part of the body into various intercommunicating sinuses, situated, some upon the median line, and others at the base of the feet. From these sinuses the blood proceeds to the branchiae, and thence into the dorsal sinus the walls of which are thin and uncontractile, and within which the heart is entirely enclosed. This dorsal sinus is filled during the systole, and the arterialized blood which it contains is absorbed during the diastole through the venous orifices of the heart, without any aid on the part of the walls of the sinus.

With the Myriapoda, also, the arterial system is highly developed. Not only are there numerous arteries arising from the sides of the heart, which ramify in the segments of the body, but also, beside an anterior dorsal aorta, two other considerable arteries which embrace the oesophagus, then bend below and unite to form, on the abdominal cord, a Supra-spinal artery. This artery gives off numerous lateral branches, which accompany the principal nerves, and terminate, at last, in ramuscles.

But what distinguish the Myriapoda from the higher Crustacea, are the venous currents, which, equally extra-vascular, do not run towards the respiratory organs, but pass directly into the dorsal sinus, and thence are absorbed into the chambers of the heart through the venous orifices.

5 Of the absence of vessels around the venous currents one may easily be convinced from an examination of small Amphipoda and Isopoda. This absence exists also with the higher Crustacea; see Duxerney, Ann. d. Sc. Nat. VIII. 1837, p. 54, or in Cuvier, Lecous d. Anat. Comp. VI, p. 404 (Scylla). I am quite of the opinion of Land and Schultz (Linn, 1830, p. 1225), who have combated the opinion of Audouin and Milne Edwards and have described the venous system of the Decapoda as having proper walls (Ann. d. Sc. Nat. P1. XXVI—XXXL). But Milne Edwards, who, at this time, advocates with so much zeal the wall-less condition of the circulating currents with Molusca, appears, moreover, to entertain the opinion of a similar circulation with the Decapoda; at least, such would be inferred from what he has said upon the circulation in general of Crustacea; see Hist. d. Crust. I. p. 101, and Cyclop. loc. cit. p. 777.

6 According to Audouin and Milne Edwards (loc. cit. P1. XXVI. fig. 3), the returning blood from the branchiae enters the heart direct through inter-anastomosing sasa branchio-cardiaca. But this statement has been reasonably doubted by various observers, for these naturalists had overlooked the sinus which envelopes the heart of the higher Crustacea, and receives, first of all, the branchial blood; see Straus, Consider. &c. p. 514; Lord and Schultz, Isis, 1830, p. 1226; and Krohn, Ibid. 1834, p. 522. This dorsal sinus has been compared sometimes to an auricle, sometimes to a pericardium; but, strictly speaking, neither of these comparisons is correct.

7 The division of the anterior dorsal aorta, with Scolopendra, was first noticed by Straus (Consider. &c. p. 347). More detailed researches on the arterial system of the same have been published by Kuntzorga (loc. cit. p. 18, Tab. III.), and Lord (Mod. Gen. part VI. vol. I. 1837, p. 892), who were chiefly occupied with the supra-spinal artery. But of all the observers, Newport (Philos. Trans. 1843, p. 274, P1. III. XIV.) has worked out the arterial system of the Myriapoda in the most complete and masterly manner. His researches have shown that this system is least developed with the Julidae, and rises gradually through the Isomeridae and Geophilidae—reaching its highest grade of structure with the Scolopendridae. Kutzorga has entirely mistaked the nature of the heart in regarding it as a vena cava, and the supra-spinal artery as an aorta. Gaede, also (Zool. Magaz. I. p. 108, Taf. I. fig. 1, p. 1), is quite in error as to the vascular system of Scolopendra; for he has evidently seen the three vessels arising from the anterior extremity of the heart, namely: the dorsal aorta and the two vessels which, uniting, form the supra-spinal artery; but he has taken them for nerves.

8 Newport, who has so well observed the circulatory system of the Myriapoda, says nothing of veins, and describes the dorsal sinus as a pericardium.
CHAPTER VII.

RESPIRATORY SYSTEM.

§ 285.

The majority of Crustacea respire by Branchiae; but among the lower orders, there are many which have no trace of respiratory organs, while the Myriopoda respire by aeriferous tracheae.

With most Siphonostoma, Lophopoda, and many Stomopoda, there are no particular respiratory organs, the respiration being, therefore, cutaneous; and with some species of these orders, the water is renewed by the ear-like action of some of the locomotive organs.\(^1\)

The Branchiae of Crustacea are sometimes lamelliform, sometimes cylindric, and often appear either distinct and separate, or consist of compound serrated organs, branched in various ways, on which the branchial lamellae are disposed in a regular row, and the branchial tubes united in larger and smaller tufts. But these lamellate or tubular branchiae are invested with a membrane so thin that it widely differs from those of the other regions of the body. It is never ciliated, and is usually without fringes, bristles, &c.

The interior of these organs presents only a few parenchymatous points, and, whatever may be their form, they are always traversed by numerous canals and large interanastomosing lacunae, which are wholly without proper walls, and are filled by the arterial and venous currents.\(^2\)

The branchiae are often in connection with their neighboring appendages. These last consist of multi-articulate lashes or cirri, or of scales, or large plates, and serve either as gyrate organs, or as opercula shielding the respiratory organs; sometimes, indeed, they perform both of these functions at the same time. Nearly always these organs are fringed with long, stiff, and often pinnate bristles.\(^3\)

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1 The branchiae are wanting with the Penellina, Lernaeridae, Ergolina, and with some Caligina. With Daphnia, Lycocera, and some other allied Lophopoda, the small ear-like feet concealed under the belly are probably designed for the agitation of the water, while the two feet projecting in front of the body, and which are larger and usually branched, are the principal swimming, organs. Indeed, even when these animals are at rest, these organs are seen in perpetual motion — thus causing in the cavity of the shell a continual current of fresh water; this supports the observation of Ehrenberg (in his third Beitr. loc. cit. p. 189, note) that, with these Encomascea, the internal surface of the valves performs the function of branchiae. The active, hairy, clavate processes inserted on the base of the first pair of feet with Cyclopina castor, and which have been usually regarded as posterior antennae (Malter, Encomascea, p. 106, Tab. XVI. fig. 6, c, or Jurine, Hist. d. Monopl. p. 52, Pl. IV. fig. 1, Pl. V. fig. 1, b. Pl. VI. fig. 13, a.), are nothing but organs for the agitation of the water. With Cypseris, only, are there perhaps special branchial organs. These little animals have at the base of the posterior pair of jaws two semilunar, pectinated plates, curved upwards, having completely the aspect of branchiae; see Randohr, Beitr. loc. cit. p. 16, Tab. IV. fig. 5, B, and fig. 8, L; also Strezus, loc. cit. p. 40, Pl. I. fig. 4, a, and fig. 8, e, or Baird, in the Magaz. of Zool. and Bot. p. 520, Pl. XVI. fig. 8. These organs appear to have been wholly misapprehended by Treadivas (Verm. Schrift. H. p. 58; Taf. IX. fig. 5). With Myrs, Leucifer, and Amphion, there are no traces of branchiae, while with the other allied Stomopoda, such as Aitna and Phyllosoma, they sometimes exist in a rudimentary form. As branchiae, have been regarded, also, the articulated processes of the eleven feet of Myrs and some other Stomopoda; but, certainly, they are organs for swimming or for the agitation of the water, and their organisation has nothing in common with that of branchiae.

2 It is owing to this small quantity of parenchyma in the lamelliform branchiae and to the numerous lacunae filled with blood that, when the circulation in these organs is arrested, the two canals of which they are composed, separate from each other, and the whole branchia, swollen from accumulated blood, has the form of an ampuulla. The blood then changes its natural color. This pathological state may be easily seen in individuals of Asellus, Gammarus, and Aps, when allowed to be a long time dying. These ampuullae are visible, with Gammarus; and of a beautiful red, with Apses; see my note upon the ampuulla of Apses canciformis, in the Ids, 1833, p. 429.

3 Hairy and bristled appendages of this nature are often taken for branchiae. These organs are not only surrounded by a thick skin which is-
The branchiae are usually inserted at the base of the anterior true feet, or the posterior false feet, floating freely in the water; or, they are contained in a special respiratory cavity, into which water is admitted through various ways.

§ 286.

The principal differences observed with the Crustacea in the disposition and structure of their branchiae, are the following:

1. Many genera of the Caligina and Argulina, have upon various parts of their body, such as the back, the abdomen, and the tail, several thin, simple, naked lamellae, which may be regarded as branchiae.\(^1\)

2. The feebly-developed branchiae of the Lepidea consist of cylindrical or lanceolate processes inserted at the base of some of the errate feet, and curved towards the back of the animal, so that they are always concealed in the cavity of the shell. But the water is renewed upon their surface by the regular movements of the long posterior feet.\(^2\) With the Balanodea, the branchiae have left the body of the animal, and are developed on the internal surface of the mantle as more or less numerous soft folds or lamellae.\(^3\)

3. With the Laemodipoda, and some Stomatopoda, the branchial apparatus is reduced to a few vesicular or cylindrical, sometimes wholly rudiment-

self would render them unfit for the respiratory function, but they are not traversed except by feeble blood-currents which do not enter the bristles or hairs. From the complete absence of ciliated epithelium, the vortex-producing organs are of much importance. On this account, many species with which these organs are wanting, use their feet for this purpose.

1 *Euryphorus* has four such polacanulate branchial lamellae on the dorsal surface of the two grand segments of the body. These are what *Milne Edwards* (Hist. Nat. d. Crust. III. p. 492, PI. XXXIX. fig. 4) has called *Appendices clypeotoides*. With *Dincentura*, the last pair of feet is changed into two naked, deeply-enshrouded branchial lamellae (*Kroyer*, Isis, 1841, p. 275, Taf. I. fig. 6, l.). With *Phyllophora*, the branchial apparatus is still more fully developed, for each foot of the last four pairs terminates with two oval, glistening, branchial lamellae (*Milne Edwards*, loc. cit. III. p. 471. PI. XXXVIII. fig. 14).

The two thin, lanceolate caudal lamellae of *Argulus*, through which pass strong blood-currents interrupted only by some islets of substance, are certainly respiratory organs to which the car-like organs which *Jurine* (loc. cit. p. 442) has erroneously considered as branchiae, serve as vortex-producing organs. I am yet undetermined if the respiration is performed by these lamellae alone, or in part by the lateral portions of the dorsal shield through which pass numerous blood-currents. But in any case, I cannot believe it possible, as has *Vogt* (loc. cit. p. 11), that these lateral portions are the only respiratory organs of these animals.\(^4\)

2 In the various species of *Lepas*, there are from two to five arcuate branchiae which hang from each side at the base of the first pair of cirri. With *Cineras*, beside the six branchiae, there is one, very short, upon the back of the animal, at the base of the third, fourth, and fifth pairs of feet; while with *Olivum*, there is a seventh pair inserted on the second pair of feet; see *Mertens in Maturer* Arch. 1855, p. 592; *Wagner*, Lehrb. d. vergleich. Anat. p. 299; *Carter*, Mem. loc. cit. p. 6, fig. 2, 5, 6; *Burmeister*, Beitr. u. c. p. 51, PI. I. fig. 14, c. e., and *Martin St. Ange*, Mem. loc. cit. PI. II. fig. 17, 18, K. K. (Lepas).

3 These branchial lamellae are extraordinarily developed with *Coronula diadema* (*Burmeister*, Beitr. u. c. p. 55, Taf. II. fig. 19, a. a.). They are few in number with *Rutulus* (*Cantier*, Mem. loc. cit. p. 14, fig. 18, c. c.). It is true that *Burmeister* subsequently (*Handb. d. Naturgeschicht. p. 551) did not regard as branchiae but rather as ovarian sacs, these organs which as to form and position correspond somewhat to the branchiae of certain Branchipoda (*Lingula*). But even if they do serve at the same time as receptacles of the eggs, this would be no reason for refusing to the folds of the mantle of the Balanidea the function of a respiratory organ, for, with other lower animals, as for example with the Lamellibranchia, the branchiae serve as receptacles for the eggs.

\(^{1}\) [§ 286 note 1.] *Legidy* (loc. cit. Siebold and Kolzlicher's Zeitsch. II. p. 357) has carefully examined the intimate structure of these caudal appendages with *Argulus*; they are composed, 1st, of simple glands such as are found under the skin over the whole body; 2nd, of a rich muscular net-work; and 3rd, of a lacunal net-work (*Lackenhaut*). The glands and the muscles constitute what is described above as the islets of substance. *Legidy* denies that these lamellae, thus composed, have, peculiarly, a gill function. — [30]
ary appendages, which hang freely from the base of some of the feet, or are inserted isolatedly on the sides of the body. 

4. The Phyllopoda have, at the base of each of their numerous swimming feet, an ovoid or lanceolate branchial lamella, pointing forwards. It is quickly distinguished by its thin, glabrous covering, in opposition to that of the other divisions of feet, which are bristled.

5. With the Amphipoda, the rapacious and ambulatory feet, excepting the first and last pairs, are those only which are provided with respiratory organs. These last consist of oval or round glabrous lamellae, situated internally at the base of the five middle feet. They receive, constantly, fresh water by the movements of the three anterior pairs of post-abdominal feet, which act as gyratory organs.

4 With Phyllorosa, there is, at the base of the anterior feet, a small, ovoid, pedunculated appendage, which may perhaps be regarded as a rudimentary branchia; see Milne Edwards, Hist. Nat. d. Crust. 11. p. 471, Pl. XXVIII. fig. 15, a. It is remarkable that, with another Scopomede genus, *Spilla*, there are at the base of the ten rapacious feet similar pedunculated appendages of the form of oval lamellae (Milne Edwards, Hist. Nat. d. Crust. 11. p. 512, Pl. XXVI. fig. 16, Pl. XXVII. fig. 13, 14, 15). These, also, would be regarded as rudimentary branchiae, did not these Crustacea have distinct branchial organs (see below). With *Alima*, the oval feet have sometimes very rudimentary branchiae in the form of simple vesicles or ramified processes (Milne Edwards, loc. cit. 11. p. 505). With *Caprella*, and *Aeginia*, the first two posterior abdominal segments have, upon the sides, a simple, very soft, pyriform branchia; while with *Leptomera*, there is a vesicle of the same nature at the base of the six feet of the first three posterior abdominal segments; see Muller, Zoöl. Danae. Tab. I. VI. fig. 5, and Tab. Cl. fig. 2; Templeton, Transact. of the Entomol. Soc. I. p. 103, Pl. XXI. fig. 7, f.; and Krøyer, Naturalist. Tablir. IV. p. 490, Pl. VI. VIII.

With Cyamus, the respiratory organs are even more developed. They consist of four long, simple cylinders inserted on the sides of the first three posterior abdominal segments, and projecting over the back; see Tremaurus or lamarckii (Aud. Nat. d. Crust. II. p. 9, Tab. I. fig. 1-3, and Boudant, Ann. d. Zool. et Physiol. p. 32; Tab. VII. fig. 45-49; also Krøyer, loc. cit. 11. Pl. X. fig. 70-76; and Roussel, De Fauénse, loc. cit. 108, Pl. VII.); according to this last mentioned author, Cyamus ovalis has four double, branchial cylinders. These branchiae of Cyamus have often been taken for metamorphosed feet, but it is only necessary to examine them in their earliest condition in order to be convinced that they are special organs (Milne Edwards, Ann. d. Sc. Nat. 111. 1855, p. 323, Pl. XIV. fig. 14). At this epoch they are as pyriform as those inserted on the side of the feet of *Leptomera*. The passage to *Spilla*, whose branchiae are more highly developed, is made by *Caprella*. Each anal foot has here a bifurcated branchia, the two cylindrical divisions of which are curved towards each other; see Milne Edwards, Hist. Nat. d. Crust. 11. p. 492, Pl. X. fig. 5.

5 The delicate branchial lamellae usually assume after death the form of vesicles, from being filled with blood, a phenomenon already mentioned (§ 285, note 2). But, formerly, they were taken for special organs whose function was unknown, and Berthold (1839, h.) has regarded them as the organs of *Aeus* as male genital organs; while the remaining pleural divisions of swimming feet were, according to him, respiratory organs.

These branchiae are easily perceived with *Aeus* after death, and from the form which they then assume, they have long been known as the problematical race (*Schnaeffer*, loc. cit. Tab. XXI. VI.; *Zadditch*, loc. cit. p. 14, Tab. II. fig. 33, B. Tab. XIV.). In 1830 (Ipsi, p. 422) I gave the correct interpretation of these organs which, like the swimming foot of *Aeus*, are lacking in the specimen from before backwards; but, already, before my, *Lacoge* (Naturforsch. Stuck. XIX. p. 69, Taf. III. fig. 6, 7, 10) had recognized their nature. With *Lamania* and *Isaura*, the branchiae are very long and of a brown-red color, but are wanting on the last swimming feet; see *Bruguière*, loc. cit. p. 86, Pl. XII. fig. 7, 8; *Straus*, Mus. Strenckii, loc. cit. p. 124, Taf. VII. fig. 13, 14, r. 15, k.; *Joly*, loc. cit. p. 239, Pl. XVII. fig. 3, 6, 7, f. and Pl. VIII. fig. 8, f. With *Chirocephalus*, *Branchipus*, and *Artemia*, they have a more oval form and exist on all the swimming feet. *Kathke* (Car Fana da der Kroya, p. 168, Taf. VI. fig. 14, 19-21) has figured, probably from dead individuals, those of *Artemia* as vesicular bodies. In the figures of *Jurine* (Hist. d. Monoc. Pl. XI. XXII.), made for the memoir of *Prevoa*, the branchiae of *Chirocephalus* are not seen at first, but with a little attention may be discovered. *Gaud* (Wiedemann's Zoöl. Magna. I. p. 88), *Berthold* (Ipsi, 1839, p. 683), Taf. VII. fig. 1j, and *Zadditch* (loc. cit. p. 11, Tab. I. fig. 17, Tab. II. fig. 10) have regarded the large dorsal field of *Aeus* as respiratory organs, since its lateral halves are traversed by blood-currents running close to each other (*Schnaeffer*, loc. cit.); and *Roussel* (De Fauênse, loc. cit. 108) considered these directly towards the anterior extremity of the heart.

Indeed, from the vascularity and delicateness of the under surface of this shield, one would be quite disposed to attribute to these parts a participation in the respiratory act.  

6 For a long time, the multi-articulated, bristled, anal feet of these small Crustacea were regarded as branchiae, for the true branchiae are quite concealed under the internal surface of the anterior feet. Even after the attention had been directed to these organs, their form was often misapprehended; for when these animals are a long time dying, their branchiae are changed, from congestion, into ambulatory. With the Amphipoda, it is easy to distinguish the branchial lamellae from the respiratory lamellae at their side, for the borders of these last are bristled; see *Straus*, loc. cit. p. 57, Pl. IV. fig. 10, II. h. (Hictta); *Zenker*, loc. cit. p. 8 (*Gammarus*), *Milne Edwards*, Ann. d. Sc. Nat. XX. 1830, p. 357, Pl. X. fig. 7, Pl. XI. fig. 1, also *Hibbs*, 111. 1835, p. 99, fig. 292, Pl. II. fig. 15, c.; *Plint*. XXX. fig. 1, 13, 19 (*Gammarus Phronimus, Fibula*, *Hyperia*). According to *Savigny’s* figure (Descrip. de l'Egypte, loc. cit. Pl. 11.)
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6. With the Isopoda, the five pairs of post-abdominal feet are nearly always concerned exclusively in the function of respiration. The two multi-articulate cirri of each of those feet, have been changed into plates, which, pointing backwards, are imbricated and applied against the under surface of the last caudal segment, which is usually very large. The form of these plates is sometimes lanceolate, sometimes discoidal or rhomboidal, and they often differ widely in the different sexes of even the same species. Upon the same foot, the external or anterior plate is usually leathery and bristled on its external border; while the internal or posterior plate is covered with a very thin envelope, and is usually entirely glabrous. This last, therefore, should be regarded as the proper branchia, of which the first is only the operculum, serving, also, often as a gyrate organ. The first case is observed with the terrestrial Isopoda, where the branchial opercula are fixed, rhomboidal, slightly concave, and completely cover the branchial lamellae preserving them from desiccation.

With most of the aquatic Isopoda, on the other hand, this apparatus is in perpetual motion, and the branchiae are often of the same form and size as the operculate plates. The opercula of the first pair are so large that they extend beyond all the rest. With the Idoteoidea, the operculate apparatus has an entirely peculiar structure. The two feet of the last caudal segment are developed into two valves which move laterally like the two folds of a door, and can open and close the branchial cavity, which is provided with five pairs of double plates. The branchial apparatus of the Bopyrina differs, in many respects, from that of the other Isopoda. With some species, it is reduced to four or five pairs of simple, superposed plates, without any accessory organ; while with others, there are four to six branchiae which, as more or less deeply fissured cordiform plates, or as long and

XI. fig. 45, 46] of Amphithoe filosa, this animal has, beside the ten round branchial lamellae, a sixth and rudimentary pair on the two posterior feet. 7
7 For the respiratory organs of the Isopoda, see especially Duverney and Lereboullet, Ann. d. Sc. Nat. XV. 1841, p. 177, Pl. VI.

8 With the terrestrial Isopoda, the branchial apparatus is somewhat abortive, for true branchiae are wanting beneath the two anterior pairs of opercula, and those back of the three posterior pairs are very small and delicate; see Trevisanus, Verm. Schriff. I. p. 62, Taf. VI. XIII. IX. (Porcellio) Savigny, Descript. de l'Egypte, loc. cit. Pl. XII. fig. 7 (Lycida), and PL XIII. (Pylos, Porcellio and Armadillidium); Brandt, Zoöl. Taf. XI. fig. 35—57 (Porcellio), and Lereboullet, loc. cit. p. 118, Pl. IV. fig. 17, Pl. V. fig. 18—22 (Lycidae). This abortion of the branchiae is compensated with some Quinqueloba by the existence of lung-like organs. (See below, § 287.)

8 Ascillus has two very large, common, anterior branchial opercula; but the branchial apparatus, moreover, is composed of only three pairs of plates on each side (Trevisanus, Verm. Schriff. I. p. 75, Taf. X. XII.), while with Sphaeroma, Cymothoa, and Allied genera, there are five pairs on each side (Savigny, loc. cit. Pl. XI. XII.).

With some species of Sphaeroma, Cymodocea, Nesoa, and Amphoroida, the branchial plates of the last two pairs of branchiae, have numerous transverse plates, which connect these Sphaeroma-toda with the Ponticopoda (Duverney and Lereboullet, loc. cit. p. 215, Pl. VI. fig. 15—23, and Milne Edwards, Hist. d. Crust. III. p. 223, Pl. XXXII. fig. 9). With Serolis, the branchial structure is quite different, the fourth and fifth pairs of feet being changed into broad branchial plates (Milne Edwards, Arch. du Mus. d' Hist. Nat. II. p. 21, Pl. II. fig. 1—6).


* [§ 286, note 6.] Leydig (loc. cit. Siebold and Kaltiker's Zeitsh. III. p. 250) does not admit that the red pouches, above-mentioned with Apus, are of a respiratory character, at least with Artemia and Branchipus, where he has examined their histological composition. In this connection it may be mentioned that this observer has found on each natatory foot of Branchipus, a peculiar and new structure. This is a roundish, dark-orange-colored, podunculated body, situated on the under side of the leg near the coxal joint. This body is composed of large nucleated cells which contain a yellowish liquid. The use of this structure is unknown. — En.
sometimes branched tubes, project considerably beyond the lateral borders of the posterior segments of the body.\(^\text{11}\)

7. The Poesiolopoda hold a place between the Isopoda and the Decapoda, their branchiae being, as in the first, inserted on the abdominal feet, and, as with many of the second, composed of numerous plates. With *Limulus*, the five posterior abdominal feet, which are inserted on the second dorsal segment, and changed, as well as the first pair of abdominal feet, into very large plates, have upon their posterior surface numerous semioval, branchial plates lying upon each other. The first pair of feet appears to play, also, at the same time, the part of an operculate apparatus.\(^\text{12}\)

8. The Stomapoda, with which the respiratory apparatus is most highly developed, have numerous branchial filaments disposed pectinately on a long stalk, and float freely in the water.

The Squillina have a similar branchial tuft on the anterior surface of the external plate of each of the ten swimming feet, which are only the ten post-abdominal feet of the posterior part of the body, transformed.\(^\text{13}\)

With *Thysanopoda*, only, these branchial tufts are inserted at the base of the anterior abdominal feet.\(^\text{14}\)

9. With the Decapoda, all the branchiae are joined together at the base of the anterior abdominal feet and of some of the foot-jaws; but at the same time they are contained in a special branchial cavity, which is covered by the lateral parts of the cephalothorax. Each of these two cavities communicates externally by two fissures. One of these is situated at the under surface of the body between the lower border of the cephalothorax and the base of the feet; through it the water enters the branchial cavity. The other is upon both sides of the masticatory organs, and through it the water is ejected. In this last, which is sometimes prolonged into a semicanal,\(^\text{15}\) are several multi-articulate cirri and lamellae, which belong to the second and third pairs of foot-jaws.\(^\text{16}\) Their continual motion produces a regular current of water from the branchial cavity outwards.\(^\text{17}\) As to the number of branchiae, there are wide differences in the various families of this order. There may be six, seven, fourteen, eighteen or even twenty-one in the same respiratory cavity. When numerous, there are usually two or three fixed on the four posterior foot-jaws, three or four on


\(^{\text{12}}\) With *Cepen*, the branchial apparatus is highly developed in that, besides the five pairs of branchiae and pretty long plates which project from the sides of the tail with the males, the five abdominal and the last caudal segment, have six pairs of long, narrow diverging lamellae with pectinated borders. *Duerxen* (*Ann. d. Sc. Nat.* XV. 1841, p. 120, *Pl. IV.* fig. 1-11), has described these twelve appendages as the principal branchiae of *Cepen*, while to me, they appear to be accessory, and are, perhaps, vortex-producing organs—the result of a metamorphosis of the anal feet. With *Jone*, all the abdominal segments have a pair of long branchial tubes pointing backwards, and with the females of this same genus, the five anterior pairs are branched on one side. In this sex, also, the organization of the Amphipoda appears to be repeated, for, from the base of the anterior feet hangs a long ridged-like band (branchia?); see *Milne Edwards*, *Hist. d. Crust. III.* p. 279, *Pl. XXXIII.* fig. 14, 15.


\(^{\text{15}}\) With many Brachyura.


\(^{\text{17}}\) *Siedow*, *Ibid.* *Pl. III.* fig. 8-10, *I.* (*Maja*).  

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Each of the four anterior pairs of feet, and one only on the last pair. With these Crustacea, moreover, the organs have no connection with the movable basal joint of the feet; but, on the other hand, most of them are inserted on the base itself of the respiratory cavity above this joint.

Many Macrura, which have numerous branchiae, are those exclusively which have one of these organs inserted on the coxa of the foot. As to their structure, these organs vary also very much. Usually, they have the form of a long, acutely-pointed pyramid with a solidly-attached base, the axis of which is formed in its whole length by a shaft traversed by an arterial and venous canal, and covered by numerous thin lamellae or cylindrical filaments, the size of which decreases gradually towards their apex.

§ 287.

Many terrestrial Isopoda have a branchial apparatus, the organization of which is entirely peculiar, and distinctly indicates a pulmonary respiration. With Porcellio, and Armadillidium, there are four white spots on the two anterior pairs of the branchial opercula. These spots communicate with as many cavities which ramify like vessels. They are situated between the two plates of these four opercula, and are filled with air. At the base of each of these opercula there is a narrow opening through which, when these cavities are compressed, the air will escape, and then the white spots disappear. By these means, these animals are undoubtedly in

18 The branchiae are forested with the Brachyura, and Carididae; among these last, Crangan and Alpheus have only six in each respiratory cavity, and Polascon and Hippolyte seven. Uca, also, has only six on each side, while with the majority of Brachyura, namely, Portunus, Grapsus, Thyophasus, Gercreatus, Pisa, Mata, Cancer, &c., there are eighteen in all, the two anterior pairs of which are usually only feebly developed and belong to the two pairs of posterior foot-jaws, while the others are in general (Main, Cancer, Lupena, &c.) so aggregated at the anterior part of the body of the respective Crayfish, that the space corresponding to the last two pairs of foot appears gill-less. The majority of the Brachyura have fourteen branchiae on each side, and these organs are even more numerous with various Macrura. Thus, I have counted eighteen with Astacus, Homarus, and Palinurus; two of which, with Palinurus, and Astacus, are in connection with the middle, and three with the posterior foot-jaw; while with Homarus, this last has also three branchiae, but the second foot-jaw has only a rudimentary one. As to the other branchiae, there is, in these three genera, a branchia inserted on the coxa of the four anterior feet. Above each of these same feet are other branchiae disposed, in couples, with Astacus, and in three above the fourth foot, with Homarus, and above the second, third and fourth, with Palinurus; while above the last foot that is gill-less, there is only a single branchia. With Nephrops, there are two branchiae on each side, and with Scyllarus, twenty-one. See, for the number and disposition of these organs with the Decapoda, Duvernoy, in Cuvier's Leçons d'Anat. Comp. VII. p. 356.

19 The various forms of the branchiae of the Decapoda may be reduced to two types. The first, the less common, exists with many Macrura, for example with Segestra, Palinurus, Gecbia, and Homarus. The shafts of their branchial arches support numerous cylinders set together in a brush-like manner. In the figures which Audoin and Milne Edwards (Anm. d. Sc. Nat. XI. 1827, Pl. XXIX. fig. 1, Pl. XXX. fig. 2, Pl. XXXI.) have given of the branchiae of Homarus, this structure may be easily seen. With Astacus, the cylinders are much less numerous, and disposed only on two of the sides of the branchial shaft,—giving it a palinate aspect; and those which are inserted on the coxae are terminated by a thin, multiplicate lamelli-form dilution, which has completely the structure of a branchial lamella (Suckow, loc. cit. p. 56, Taf. XI. fig. 18), and Taf. XI. fig. 23). With Homarus, and Palinurus, also, the coxae have an analogous plate inserted close by the side of the coxal branchia; but it is of a leathery consistence and covered with numerous hairs, so that it cannot participate in the function of respiration, but is probably only a septum to separate the different groups of branchiae. Aristes, which has sixteen branchiae on each side, differs widely from the other Macrura in having its pendenfima branchia composed of a shaft from which pass off right and left numerous curled filaments whose convex border is covered by tufts of very distinct thick-set branchial cylinders (Duvernoy, Anm. d. Sc. Nat. XV. 1841, p. 104, Pl. V.). The second type is formed by these branchiae to the shafts of which adhere at right angles numerous thin sometimes riomboidal, sometimes spheroidal lamellae, contiguous, and decreasing in size towards the apex of the shaft. This type occurs especially with the Brachyura, the Anomura, and with Galithea of the Macrura; also of the Carididae, with Polascon, Hippolyte, Alpheus, Peneus, Crangon, &c.; see Audoin and Milne Edwards, Anm. d. Sc. Nat. XI. 1827, Pl. XXVI. and XI. 1839, Pl. III. fig. 1, Pl. IV. fig. 1, 4 (Main, Romina, Polastea); also Kröger, loc. cit. Tab. I.—V. (Hippolyte), and Joly, loc. cit. p. 71, Pl. III. fig. 24 (Caridina).
a condition to respire atmospheric air.¹ But with Tylos, this pulmonary apparatus is still more highly developed; for, under the four pairs of opercula, there are, instead of simple branchial plates, oblong appendages on which is a transverse row of aeriferous sacs having a kind of stigma on their under surface.²

All the Myriapoda respire by true tracheae. Their blood does not require, therefore, special organs to receive the influence of the air, for this last is carried into every part of the body.

The stigmata for the ingress and egress of the air, are easily seen with the Chilopoda, for they are usually surrounded with a ring of brown chitine, and situated on each side of the body between the base of the feet and the dorsal shields; they are not found, however, above all the feet, for the segments which have them alternate more or less regularly with those that are without them.³ With the Chilognatha, the very small stigmata are on the ventral surface. They are situated on the anterior border of the ventral plates, from the posterior border of which arise the feet.⁴ The intimate structure of these tracheae, which are usually brown, is exactly like that of those of insects.⁵ Among the Chilognatha, the Julidae are noticeable for the very simple character of their tracheal apparatus. Each stigma leads into a tuft of tracheae from which arise air-canals which neither ramify nor Anastomose but gradually become smaller and smaller and surround the various organs.⁶ With the Glomerina, on the contrary, the tracheae, which arise from the stigmata by two trunks, are branched, but do not anastomose with the neighboring branches.⁷ Those of the Chilopoda most closely resemble those of the Insecta, — being very ramose, and their large trunks intercommunicating at their origin by longitudinal and transverse anastomoses, so that each stigma can introduce air into the entire tracheal system.⁸

¹ According to Duvernoy and Lereboullet (loc. cit. p. 231, PI. VI. fig. 14), these cavities secrete a liquid for the moistening of the branchiae. See upon this subject, my observations in Muller's Arch. 1842, p. 141, note 2.
³ With Lithobius, there is a stigma above the first, third, fifth, eighth, tenth, twelfth, and fourteenth pairs of feet (Trevisanum, Verm. Schrift. II. p. 29, Taf. IV. fig. 7, Taf. VI. fig. 5). With Scalopendra, the stigmata have a similar disposition (Kutorga, loc. cit. p. 14).
⁴ See Savi, Lc., 1825, p. 219, Taf. II. fig. 9, a. a., and Burmeister, 1834, p. 134, Taf. I. fig. 2, a. a. (Julus). These stigmata with Julus were entirely overlooked by Trevisanum. He had regarded as such the orifices of a row of glands which are situated on the sides of the segments of the body (Verm. Schrift. II. p. 42, Taf. VIII. fig. 4, 5, 6, 7).
⁵ The characteristic spiral filament of the Insecta is also not wanting here; see Kutorga, loc. cit. p. 14, Tab. II. fig. 8.
⁶ Savi, Considerat. Ec. p. 207, and Burmeister, loc. cit. Taf. I. fig. 3 (Julus).
⁷ Brandt, in Muller's Arch. loc. cit. p. 225, Taf. XII. fig. 4, 5 (Glomeris).
⁸ Savi, loc. cit. p. 207, and Traité d'Anat. comp. II. p. 103; Trevisanum, Verm. Schrift. II. p. 50, Taf. VI. fig. 6 (Lithobius), and Muller, 1825, p. 581, Taf. II. fig. 1.
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CHAPTER VIII.

ORGANS OF SECRETION.

I. Urinary Organs.

§ 288.

As yet, Urinary organs have not been observed with the Crustacea except in the Myriapoda. Here, as with the Insecta, they consist of long, small, brownish vessels, caecal, and describing many convolutions about the stomach and intestine. These Malpighian vessels, as they have been termed, open into the digestive canal at the boundary between the stomach and intestine, and secrete as certainly as do those of the Insecta, uric acid. With the Chilopoda, there is usually one on each side of the pylorus; but with the Chilognatha, there are two, which open, however, into the intestinal canal by a common orifice.

It is now undetermined whether these organs exist also in the other families of Crustacea. But with some Decapoda, there are certain caecal vessels which are imperfectly known. They open into the intestine at various points between the pylorus and rectum, and a more complete examination may, perhaps, show them to be of a urinary nature.

II. Organs of Special Secretions.

§ 289.

The Astacina have a very remarkable secretion commonly known as Crabs-eyes. These are a kind of calculi composed of carbonate of lime.

1 For the Malpighian vessels, which were for a long time regarded as biliary canals, see further under the anatomy of the Insecta.

2 Ramadori, Abhandl. über d. Verdaunungsw. &c. p. 149, Taf. XV. fig. 1 (Julus); Tippeirinus, Verr. Schrift. loc. cit. p. 21, 46, Taf. V. fig. 1, Taf. VIII. fig. 6 (Lithobius and Julus), and L. Dufour, Am. d. St. Nat. loc. cit. p. 86, 96, Pl. V. fig. 1, 4 (Lithobius and Scutigera). Scutigera differs from the other Chilopoda in having two pairs of urinary canals.

See also Kutorga, loc. cit. p. 6, Tab. 1. fig. 2, and Muller, Isis, 1829, p. 550, Taf. II. fig. 5 (Scolopendra); Emily Brandt, in Muller's Arch. loc. cit. p. 322, Taf. XII. fig. 2 (Glosmeris).

3 Suammandam (loc. cit. p. 87, Taf. XI. fig. 3) had already figured, with Pagurus, a pretty long caecum opening at the posterior extremity of the intestine. With Maia squinado, there are three such pretty long, of which two are inserted on each side of the pylorus, and the third a little further behind (Milne Edwards, Hist. Nat. d. Crust. I. p. 76, Pl. IV. fig. 1, m. n.). Land (Isis, 1822, p. 1302) has also seen two glandular canals rolled up in a knot, which open each side of the pylorus, while a third entered the rectum. This last, according to Cuvier (Leçons d'Anat. Comp. III. p. 675) is very common with the Macrura, Brachyura, and Anomura, and notably with Astacus fluviatilis, Homarus marinus, Cancer pagurus, Portunus puber, and Cancer maenas. But although Milne Edwards admits the same also (loc. cit. I. p. 78), yet it does not appear to be agreed upon, for Meckel (Syst. d. vergleich. Anat. IV. p. 161) contradicts Cuvier in this respect, and declares that he has never found this caecum either with the Crabs or with Astacus, Scyllarids, and Palinurids, but only with Pagurus, Penaeus, and Palaemon. Duvernoy, also (Leçons d'Anat. Comp. V. p. 228), has not observed it in the Macrura just cited, nor with Galathea squamifera, and Palaemon serratus, although he perceived it with Portunus puber directly behind the pylorus, and with Cancer pagurus, near the rectum. Like Milne Edwards (Hist. d. Crust. I. p. 115, Pl. X. fig. 2, j. (Muss), I must leave undetermined the point whether or not, this glandular mass which, with the Decapoda, is concealed under the floor of the respiratory cavities in the bottom of the cephalothorax, and which opens externally by an excretory canal between this same cephalothorax and the first abdominal segments, is really a urinary organ.
and formed in the two lateral pouches of the stomach of the *Astacus fluviatilis*.\(^1\) As they are not observed during the whole year, but only just before the molting, and as, when this process occurs, they pass from the cast-off stomach into the cavity of the new one, it may be inferred that they are in some way connected with the act of ecdysis, and that if the lateral pouches of the stomach secrete from the blood the excess of calcareous salts, it is in order that these last may be subsequently used for the formation of the new shell.\(^2\)

The caustic, brown fluid, which most Myriapoda, when touched, emit from a row of orifices situated on the sides of the segments of the body (*Porodinu repugnatoriuca*), and which exhalates an odor like that of chlorine, is secreted by small, pyriform, glandular follicles, situated immediately beneath the skin. Its use is, perhaps, for the lubrication of the articulations of the segments of the body.\(^3\)

In the following chapter will be mentioned many other glandular organs connected with the genital functions.

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\(^1\) See *Suctson*, loc. cit. p. 53, Taf. X. fig. 10, 11, e. This author is mistaken in supposing that these glandular bodies mentioned in connection with the organs of hearing (§ 270), secrete the "Crab-eyes." See also *Brandt*, Mediz. Zool. 11. p. 63, Taf. XI. fig. 8, 9, e.

\(^2\) For the nature of these crab-eyes, see the researches of *Ruer* (Muller's Arch. 1834, p. 530) and *Oestertcl*, Tbid. 1849, p. 432.

\(^3\) *Trestramnu* (Verm. Schritt. II. p. 42, Taf. VIII. fig. 4, 5, 6, 7, d. c.) has regarded these organs as respiratory with *Julius*, while *Sant* (Isis, 1823, p. 218, Taf. II. fig. 1, 13, 14, a. d.), and *Buirnisteir* (Tbid. 1834, p. 106, Taf. I. fig. 1, a. a.) have well perceived that they are cutaneous glands. According to *Waga* (Revue Zool. 1839, No. 5, p. 76, or in Wiesmann's Arch. 1849, II. p. 550), *Polydesmus*, *Platapalus*, and *Oecophillus electricus*, have, upon the sides of the body, analogous glands, out of which this last Myriapod emits a luminous liquid. *Brandt* (Recueil, &c., p. 154, 155) has observed, with *Gomera*, that these follicles are situated, in pairs, on the dorsal surface of each segment of the body.*

1 This is so with the *Buphiidii*, *Cyriiciidae*, and *Apodii*. In the second of these groups, the males are so rare, that these Entomostraca have been taken for hermaphrodites, and *Streps* (loc. cit. p. 52, Pl. 1. fig. 10) has said that if this was really the case, he regarded as testicles two long cylindrical problematical bodies which he had observed with all the females of *Cypris*. In the genus *Apus*, no individuals which can with certainty be regarded as males, have been found. *Berthold* (Isis, 1830, p. 693) has taken the red ampullae found with these Crustacea for testicles; but, as I have already remarked, these ampullae are only branchial lamellae filled with blood during the dying of the animal. (See § 256, note 5.)

\(^*\) [§ 289, note 3.] These odoriferous glands have been successfully studied by *Leidy* (Proc. Acad. Sc. Philad. 1840, IV. p. 255) with *Julius*. Here, they consist of a globular body or sac, with an elongated conical neck, and resemble in form a florescence flask with the mouth drawn to a point. This sac is composed of a basement membrane lined with a single layer of secreting cells. The neck of the glands has muscular bands. — *Eh.*

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**CHAPTER IX.**

**ORGANS OF GENERATION.**

§ 290.

The Crustacea reproduce by Male and Female Organs, situated in different individuals, and have, for the most part, copulatory organs.

Nevertheless, the Cirripedia form an exception in this respect, being hermaphrodites; while, on the other side, many Entomostraca differ from the general rule, in their species being almost exclusively females, which produce, during many successive generations, individuals exclusively of the female sex, and only at long intervals, those of the male sex.\(^1\) There is,
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probably, some relation between this remarkable mode of generation and the fact that some females lay two kinds of eggs, one of which is developed spontaneously, that is, without the influence of sperm, while the other requires to be fecundated. 2

The structure and disposition of the genital organs is so different in the various divisions of Crustacea, that it is difficult to make any general statement about them. Usually, there is a complete duplication of these organs, internal and external, with both sexes. With the females, there is nearly always, right and left, a longer or shorter, rarely-branched, ovarian tube. This is succeeded by a narrow oviduct, usually long, and often flexuous. This last continues into a large vagina, which opens at very different points on the ventral surface, sometimes quite in front, sometimes near the middle, or at the posterior extremity. It is rare that this vagina has a Receptaculum seminis; but, more commonly, the females have special glandular canals annexed to the genital orifice. The product of these last is a viscous nectar, which hardens in water, and serves to envelop the eggs, and to glue them together. The eggs, thus bound together in chaplets or clusters, remain glued to the parts neighboring the genital orifice, or to the post-abdominal feet, and are borne about by the females, until the embryos are fully developed. With other females, where these organs are wanting, they are replaced by a special pouch (Marsupium) situated, usually, at the inferior surface of the thorax. In this pouch the eggs are deposited and remain until their embryos are completely developed.

With the males, the internal genital organs are disposed in a similar manner, and often have the same form as those of the females. A careful examination is, therefore, necessary, to perceive their distinctive character. Moreover, they open, also, at the most varied points of the body. In many species, there are, near the genital orifices, copulatory organs in the form of stylets, or canaliculi, which serve to transfer the sperm into the female organs. With others, the antennae, or some of the feet, are provided with a kind of hook, or pincers, with which they seize and retain the females during copulation. Sometimes the internal organs of the left communicate, by anastomoses, with those of the right side, or, in the place of two lateral genital openings, there is only one, situated on the median line. With many species, the genital organs, internal and external, are simple, and placed in the axis of the body; but it is rarely observed, that the oviducts and deferent canals are single where the ovaries or the testicles are double, or that there are two genital openings for single internal organs.

The Eggs of the Crustacea are usually of either a lively green, yellow, or violet color. They are always spherical, and composed of a dense chorion, containing a vitellus, which surrounds a germinative vesicle, with one or more nuclei. The vitellus is composed of numerous oil-globules, which are held together by a clear, albuminous liquid, and give the egg its peculiar color. 3

The sperm is white and sometimes opalescent. The spermatogenous particles are of very varied and remarkable forms. Nearly always, they are

2 This phenomenon is undoubtedly analogous to that of the alternation of generation, which is so general with the other lower animals.
3 For the eggs of Crustacea, see Rathke, De Ani-
stiff and motionless, and may be arranged under the following principal types.
1. With the Cyclopidae, and Chilognatha, the spermatic particles, which are developed in cells, retain their cell-form to their perfect state, without any trace of processes or appendages.\(^4\)
2. With the Decapoda, they are likewise nearly always of a granular or cell form, but have small, filiform, sac-like processes; sometimes they are divided into two portions by a constriction.\(^5\)
3. With the Mysina, Amphipoda, and Isopoda, they have the form of very long threads, pointed at both extremities, or with a cylindrical incassation at one of them. They are motionless, and, upon the addition of water, do not roll up in a loop-like manner.\(^6\)
4. With the Cirripedia, and Chilopoda, they are capillary, very lively, and, from contact with water, become entangled, forming loops and rings.\(^7\)

\(^4\) With *Cyclopsina castor*, the spermatic particles are small, finely-granular, oral corpuscles (see my Beitr. zur Naturk. d. wirbellosen Th., p. 41, Taf. II. fig. 41-43, c., or Ann. d. Sc. Nat. XIV. 1840, p. 36, (V. B.). As to the other Encommoda, we have not yet sufficient data to say anything in general. But the form observed with *Cyclopsina castor* cannot be regarded as a typical one with those animals, for *Wagner* (Wiegmann's Arch. 1836, 1. p. 593) has observed large, filiform, flexu- ous, spermatic particles with *Cypria*. 1, myself, have found those of *Daphnia rectirostris* to consist of a long, semi-circular body, which became motionless and disappeared by bursting on the addition of water. *Stein* (Müller's Arch. 1842, p. 263, Taf. XIV. fig. 57, 490) has rightly figured those of *Giemeris* as fusiform cells; but he was less exact with those of *Julius* and *Polypleus*, in describing them as small transparent vesicles (Ibid. p. 56, 59.)

With *Julius subulatus*, they look exactly like very short cylinders containing a very distinct, round nucleus. With *Julius hispidus*, they are of the same form, but are not nucleated; while with *Julius terrestris*, they are conical and nucleated (see my notice in *Müller's Arch.* 1840, p. 15). Those of the *Dileptus* are also, of a ciliated form; see Frey and *Leuckart*, Beitr. loc. cit. p. 135, Taf. II. fig. 21 (Caligus).

\(^5\) *Hendie* (Müller's Arch. 1856, p. 603, Taf. XIV. fig. 12) and *Müller* (Ibid. 1836, p. 26, Taf. III. fig. 25, 24) first called attention to the singular form of the spermatic particles of the common craw fish; but, subsequently, *Külker* (Beitr. Sc. 1841, p. 7, Taf. II. 11 and in the Schweizerisch. Denkschrif. f. d. gesamm. Naturw. VIII. 1846, p. 30, Taf. II. 11) has shown that those of the most diverse species of *Brachyura*, *Anomura*, and *Macra- ra*, are motionless, radiated cells, one part of which is separated by a constriction, and prolonged sometimes into a kind of peduncle; the rays are often only three or four in number, and the cells themselves are sometimes conical or cylindrical. The most simple of those spermatic particles are observed with *Crangon vulgaris*, and *Palaemon squilla*; and, according to my own observations, consist only of flattened cells with a short pointed process.

\(^6\) Simple capilliform spermatic particles are found with *Nyys*, *Oniscus*, *Porcellio*, *Bolboc*, and *Gammarus*; see my researches in *Müller's Arch.* 1836, p. 27, Taf. III. fig. 19, 20, and Ibid. 1837, p. 453; also *Külker*, Beitr. loc. cit. p. 15. This last naturalist (Beitr. kre. p. 14, Taf. III. fig. 28, 29) has stated that the long capillary, but motionless spermatic particles of *Iphimedia obscurae* and *Hypcria medicus* are terminated by a cylindrical and slightly flexuous incassation. I have found those of *Astilus aquaticus* to be similar, but the cylindrical extremities were straight.

\(^7\) The spermatic particles of the Cirripedia, which are simply capillary and very active when fully developed, have been observed by me (*Müller's Arch.* 1836, p. 29), with *Palanus pusillus*, and by *Külker* (Beitr. p. 16, Taf. III. fig. 30, and Schweiz. Denks. loc. cit. p. 53) with many other species of *Palanus*, and with *Cathamanus*, *Lepas*, and *Pollicipes*. Those of *Lithobius* and *Geophilus* present a remarkable aspect from their extreme activity, and may well be recommended for study from their size (*Stein*, in *Müller's Arch.* 1844, p. 259, Taf. XIII. XIV. fig. 18-83). *Trechurus* (Vern. Schrif. 11. p. 26, Taf. VI. fig. 2, 3) has taken those of *Scalopendra*, which are bound together in a long white cord, for a Helmuth.\(^*\)
§ 291.

THE CRUSTACEA.

With very many Crustacea, the sperm, at its emission, is contained in capsules (Spermatophores).

I. Hermaphrodite Crustacea.

§ 291.

With the Cirripedia, the male and female genital organs are quite removed from each other. With the Lepadida, the ovaries are lodged in the upper extremity of the peduncle and in the midst of the spongy substance, filling its cavity. They consist of ramified caeca, while with the Balanodea, the ovarian follicles are situated between the lamellae of the mantle. With the Lepadida, the canal which extends from the lower extremity of the shell into the peduncle and communicates by a narrow opening with the cavity of the mantle, may properly be regarded as an oviduct. But new researches are required to show by what means the eggs of the Balanodea reach this same cavity, for, as is the case with the Lepadaea, they remain there until the embryos are fully formed. These eggs, of a blue or yellow color, are always intimately glued together, and form, after the laying, a large sheet or layer which, with the Balanodea, is applied to the internal surface of the mantle, and often retained there by the branchial lamellae; while with the Lepadida, it covers, bonnet-like, the rounded portion of the body.

The Testicles are composed of numerous ramified follicles spread out between the skin and the two sides of the digestive canal. They join from the right and left into two very long and tubular Vasa deferentia which accompany, serpentine, the alimentary canal to the anus, and then blend together, forming a more narrow Ductus ejaculatorius. As this last traverses the whole tail and opens at its extremity, it has been usually regarded

1 Burmeister (Belts. p. 46), and Wagner (Muller's Arch. 1854, p. 469, Tab. VIII, fig. 50), were the first to notice the ovarian follicles of the foot of the Lepadida, the first with Otios, the second with Lepas. Martin St. Anges (loc. cit. p. 20, PI. I, fig. 10, 11) has verified this fact with this last genus. I have found them also in the foot of Cymbas, and I will remark that in the remaining spongy substance of this foot, there are other round uniloculated bodies which appear to be solid concretions, and should not be confounded with the germs.

2 The ovaries of the Balanodea are more difficult of study than those of the Lepadida, probably because they are scattered in the walls of the mantle, and consequently scarcely visible, especially when empty. It is undoubtedly on this account that Poli (Testac. uritus, Sicil. &c. I. p. 19, 28, Tab. IV. fig. 13, &c. Tab. V. fig. 15, 18) has likened them to ovaries, with a Balanus, the testicular follicles, although he distinctly saw and has figured the ovarian follicles in another species of this same genus.

3 This canal, regarded as an oviduct by Wagner (loc. cit.), had already been mentioned by Cuvier (Mem. loc. cit. p. 4, fig. 4).

4 With Balanoida, the layers of eggs form usually two large discs (Poli, loc. cit. Tab. IV. fig. 13, &c.)

5 Burmeister, the whole subject of the spermatic particles of the Crustacea is sadly deficient in well-authenticated observations, and particles and cell-like forms are constantly described as spermatic particles, which, according to all the laws of Spermatogeny as yet known, cannot be such. It should be remembered that the spermatic particle is never a cell, but is the metamorphosed nucleus of a cell; it is, therefore, always a more or less solid corpuscle (whatever be its form, &c.), and to which, moreover, there may be attached one or more appendages — Ec.
ed as a Penis. (5) The length and mobility of this tail is such that it can be used, with the Cirripedia, as a copulatory organ, and, being brought in contact with the orifice of the oviducts, which is situated on the mantle, self-impregnation may thus take place.*

II. Female Crustacea.

§ 292.

The female genital organs of the Siphonostoma and Lophypopoda consist nearly always of two long and sometimes flexuous ovarian pouches, situated on both sides of the digestive canal. The oviducts pass backwards and terminate on both sides of the end of the body by separate orifices, or by a single genital opening on the median line. With those species whose body has a tail, these orifices are not situated like the anus, at its extremity, but at its base. Very often, they serve as the outlets of the excre- 
tory ducts of two caecal organs which secrete a viscous substance by which the eggs are glued together in clusters or oocytes. (6) Not unfrequently, there are hook-like or capsular appendages near the retention of these clusters. (5) But these are wanting with the Daphni- 
oidae, there being in their place an incubating cavity, situated between the

5 Cuvier (Mém. loc. cit. p. 9, fig. 8) has taken, with Lepas, the testicles for the ovaries, and the Vasa deferentia for the testes. This error could not be rectified until the discovery of the true ovaries (see Burmeister, Beitr. loc. cit. p. 53, Tab. II. fig. 10; Wagner, in Müller's Arch. loc. 
cit. p. 462; Tab. VIII. fig. 8; and Martin St. Ange, loc. cit. p. 21, Pl. II. Lepas). It is more singular to see Goodric (Edinb. New Philos. Jour. 1843, June, p. 88, Pl. III. IV. or Ann. d. Sc. Nat. L. 1844, p. 107, Pl. XV. C. or Forpile's neue Notiz. No. 631, 1844, p. 161), endeavor to confuse this question by declaring the hermaphroditic animals of Balanus to be females which carry, in the cavity of their mantle, discidium and abnormally-formed males. Very probably those so-called males are parasitic Crustacea, as Toöliker (Schweiz. Denks. loc. cit. p. 18) has supposed.

The female genital organs are completely double both with the Penellina, the Lernocidae, the Ergasilidae and the Caligina; see Nordmann, loc. cit. p. 6, Tab. I. fig. 4, Tab. V. fig. 7, Tab. VI. fig. 10 (Lam- 
chelastium). This last-mentioned author was the first to notice the organs which, in various Crustacea, secrete the viscous matter mentioned in the text. He found them highly developed with the Nicalinae (loc. cit. XX. p. 160), where they extend, with the ovaries, even into the wing-like appendages of this parasite. The ovarian follicles of Chondrobranchus, which are multiforme, differ very much from the usual form (Rathke, Ibid. XX. p. 123, Tab. V. fig. 18). With the Cyclopatae, there is only a single genital opening, although the ovaries and the or- 
gans secreting the viscous matter are double. But with Arzuga, the female genital organs are the most simple, consisting only of a single ovarian tube, opening at the base of the tail (Jurine, loc. cit. p. 448, Pl. XXVI. fig. 3.)

2 Nordmann, loc. cit. p. 8, Tab. II. fig. 6 (Er- 
gastius).

* [§ 234, end.] That the Cirripedia are not uni- 
versally hermaphroditic, was first discovered by Goodric (Ed. New Philos. Jour. XXXV. p. 88), upon Balanus balanoides. The male is very small, and it is not strange that it before eluded observa- 
ton. 

Darwin has made some researches, lately, with a similar result in some respects. Exceptions to the rule were found by this naturalist in the genera Ibla and Scaphenula. With Ibla, the males lie within the sac of the female, and have an elongated body with a pedicle below. He has also observed that, with these genera, there are both females and hermaphrodites; and in some hermaphrodites, males have been observed so similar in general character to those of Ibla, that he considers them to be true males of the species with which they are connected. Being thus supernumeraries, he has termed them complemental males. As spcrmatic particles were distinctly observed in them, their mate nature is clear, but it would not appear equally clear that they really belong to the genus and species with which they are connected. Facts so singular require further research. See Darwin, Monogr. &c. loc. cit. p. 207, 231. — Ed.

† [§ 232, note 1.] For further details on the fe-
male genital organs of Arzuga, with illustrations, see Leydig, loc. cit. in Siebold and Kölker's Zeitsch. 11. p. 339, Taf. XIX. fig. 5, a. Taf. XX. 
fig. 8, 10. — Ed.
shell and the posterior part of the back.\(^3\) The females of *Daphnia* have, beside those eggs which are rapidly developed in this cavity, another kind known as the hibernating eggs, and in which no germinative vesicle is observed. They are always found in couples in a thickened, saddle-like portion of the shell of the animal, which is often of a black color, and separated from the shell by a kind of moulting. Thus enveloped in a bivalved capsule, they are protected against the severities of the winter.\(^4\)

Among the Phyllopoda, the Apodidae are distinguished for the very large, multiramous, ovarian follicles which border the two oviducts on every side; these last are straight and large, and situated on the side of the digestive canal. With *Apus*, each of them sends off, at about its middle, a short, excretory canal, to the eleventh pair of feet, in which there are two alveolate receptacles with covers for the reception of the eggs.\(^5\) With the Branchiopoda, the ovaries consist of two straight coca, situated in the tail, on each side of the intestine. Their upper extremity, beneath the last pair of feet, passes into an elongated receptacle. These two receptacles, separated from each other only by a thin partition, have a narrow outlet at their posterior extremity, and form, under the base of the tail, a kind of oblong tumor, into which the hard and granular eggs are constantly cast from the contractions of special muscular bands.\(^6\)

There are, moreover, on the sides of the body above the last pair of feet, two oblique horny plates, which the males, during copulation, seize with their cephalic pincers.

With the Pooeloipoda, the cephalothorax contains two ramified ovaries,

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3 See Straus, Mém. sur les Daphnies, loc. cit. p. 415, Pl. XXIX. and Jurine, Hist. d. Monocel. Pl. VIII—XVI. The genera *Acutus* and *Cypria* differ, moreover, from the other Entomostraca, in that they do not bear their eggs after laying, but deposit them on foreign bodies; see Jurine, Mémm. sur l’Aponie, loc. cit. p. 451, and Straus, Mém. sur les Cyprides, loc. cit. p. 54. 4 The formation of the saddle, which is intimately connected with the deposition of the hibernating eggs, has been called by Jurine the Maladie de la selle. But it has been before observed by Muller (Entom. mer. p. 84, Tab. XI. fig. 5—11, Tab. XII., fig. 5), and by Eincodr (loc. cit. p. 22). See also, Straus, loc. cit. p. 415, Pl. XXIX. fig. 16, 17, and Jurine, Hist. d. Monocel. p. 120, Pl. XI. fig. 1, 4. 5 See Schaeffer, Der krebsartige Kiefernfas, p. 79, Tab. IV. fig. 2—7, and Zaddack, loc. cit. p. 51.
the large oviducts of which open at the base of the first pair of feet, near the median line of the body.\footnote{Van der Hoeven, loc. cit. p. 21, Pl. II. fig. 15, Pl. III. fig. 3 (Linniata).}

With the Lamelippoda, Isopoda, Amphipoda, and Mysina, there are two simple ovarian tubes wound about the digestive canal; these oviducts are sometimes terminal, sometimes lateral. The two vulvae are usually situated on the internal side of the fifth pair of feet.\footnote{There are two ovarian tubes, each continuous posteriorly into a short oviduct with Cyamus (Roussel de Vauzème, loc. cit. p. 255, Pl. IX. fig. 19), with Aegia (Rathke, Nov. Act. Nat. Cur. XV. p. 32, Tab. VI. fig. 17), and with Myopia (Frey, loc. cit. p. 25). The two oviducts meet in a common valve in front of the anus with Bopyrus and Phrygus (Rathke, De Bopyro, &c., p. 10, Tab. I. fig. 7, and Nov. Act. Nat. Cur. XX. p. 47). With the Mysina, the ovarian tubes are connected at both of their extremities; the oviducts pass from laterally and open in the articulation of the fifth and sixth segment of the body (Brandt, Mediz. Zool. II. p. 76, Tab. XV. fig. 32). I have observed an analogous structure in the genital organs of Iotheca (Müller's Arch. 1837, p. 434). With Caprella, the ovarian tubes are coiled in the same way, but they interanastomose by two pairs of short, transversal oviducts (Goldobin, Edinb. New Philos. Journ. July, 1812, p. 184, Pl. III. fig. 2). This author adds, contrary to all analogy, that these oviducts terminate in two vulvae situated one behind the other on the middle of the belly.}

9 The incubating sac of Cyamus and Caprella is composed of four lamellae situated back of the branchial upon the two hindmost segments of the body (Roussel de Vauzème, loc. cit. p. 219, Pl. VIII. fig. 3, and Goodier, loc. cit. p. 105, Pl. III. fig. 3, 10). With Myopia, this cavity contains also four lamellae covered with stiff bristles and attached to the coxæ of the last two pairs of feet (Müller, Zool. Dasc. Tab. LXVI. fig. 1, 2; Milne Edwards, Hist. d. Crust. Pl. XXXVI. fig. 8, 9; and Rathke, in Wiegmann's Arch. 1839, I. p. 199). With Nereocystis, there are also four large lamellæ arising from the coxæ of the sixth and seventh pairs of feet. With Iotheca, the Asellina, and the Gammarina, on the other hand, the five anterior segments of the body have as many pairs of ventral lamellæ of this kind. With Gammarus, the borders of these ten lamellæ are covered with long bristles (Zenker, loc. cit. p. 8, fig. N. b.). With Cyamous, the coxae of the first six pairs of feet have a similar lamella (Milne Edwards, Ann. d. Sc. Nat. III. 1835, Pl. XIV. fig. 2, and Cyclop. loc. cit. p. 734. fig. 420). The same is true of Anilocra, judging from Savigny's figure (loc. cit. Crust. Pl. XI. fig. 167). With Bopyrus, and Phrygus, the incubating sac contains six pairs of lamellæ which, in the first of these genera, are not wholly superposed (Rathke, De Bopyro, &c., p. 6, Tab. I. fig. 5, and Nov. Act. Nat. Cur. XX. p. 44, Tab. I. fig. 12). The sixth or anterior pair of these lamellæ is wanting with Cepon (Duvernoy, Ann. d. Sc. Nat. XV. 1830, Pl. IV. fig. 2), but with the Bopyrina in question, is singularly attached to the head. According to Treviranus (Vern. Schrift. I. p. 61, Tab. IX. fig. 52), there are at the bottom of this sac with Oniscus, four short conical processes which secrete a yellowish fluid, but Brandt (loc. cit. II. p. 72, Tab. VII. fig. 2, Tab. XV. fig. 30) was unable to find them, while Rathke (loc. cit.) has been led to regard as secreting organs also, two filaments which, with Myopia, are attached to the ventral wall, and stretch into the incubating sac.\footnote{The origin and disappearance of the incubating lamellæ have been very distinctly seen with Iotheca entomon (Müller's Arch. 1837, p. 433). The females of Cyamus which Müller (Zool. Dasc. Tab. CXXIX. fig. 16), and Treviranus (Vern. Schrift. II. Tab. I. fig. 2) have figured, appear to have been individuals whose incubating sac was not then fully developed.}

10 The ovaries of Squilla are so intimately blended in part with the liver, that they may be easily confounded with that organ. In this genus, the ovary is seen in cross section (Ann. d. Sc. Nat. III. 1836, p. 245, Pl. XV. and VIII. 1837, p. 42, Pl. II.) of this organ with this same animal, is not
With the Brachyura, the cephalothorax contains four long ovarian tubes, two anterior, and two posterior. The first wind outwardly over the liver, and are Anastomosed by a short transverse canal; while the second are straight, lie close to each other, and cover the anterior part of the intestine. The anterior and posterior tubes of each side unite in a short vagina, and, at their point of junction, open into a pyriform sac, which has been regarded by some as a *Bursa copulatrix*, and by others as a gland secreting the viscusous substance which envelops the eggs, but which, upon a more careful examination of its contents, will be found to be a *Receptaculum seminis.*

The two vaginas open near the ventral median line in the segment which bears the third pair of feet. With the other Decapoda,—the Anomura and the Macrura,—these sacs, just mentioned, are wanting, while the ovaries themselves are disposed, in general, like those of the Brachyura. But the genera *Pagurus* and *Astacus*, alone, form an exception in this respect. In the first, the two ovaries with their oviducts lie concealed principally beneath the dorsal surface of the tail; while in the second, they are aggregated in a trilobed mass in the pyloric region, from which pass off two short oviducts. The female genital openings are situated, with the Anomura, as with nearly all the Macrura, in the coxal joints of the third pair of feet.

With the females of all the Decapoda, the feet of all the caudal segments are highly developed and very hairy. They serve to support the eggs which are glued together in clusters by a viscid substance which hardens in water; these clusters are attached to the bristles or hairs of these feet. But with the Brachyura, and Anomura, these eggs have an additional protection in the tail, which is folded against the body.

The Chilognatha have only a single long and large ovarian tube, provided with two short oviducts which are narrower, and open externally at two squamous bodies situated on the under surface of the third segment of the body. These two bodies contain two short ovaee one of which is dilated at its base into a vesicle, and each pair opens by a common orifice in the vulva. They represent a *Receptaculum seminis.* With the perfection of the naturalist has, moreover, regarded a large part of the ovaries as venous sinuses, and the white eggs which they contain as coagulated blood. In order to have a general idea of the disposition of the female genital organs with these animals, it is only necessary to cast a glance over Delile Clige's figure (Descriz. &c. Tav. LXXXVI. fig. 4); it is true that he has represented them as testicles, but they are perfectly exhibited, with the exception, however, of the anterior portion.


13 See Cavolini, loc. cit. Taf. II. fig. 2, a. (Grampus); Milne Edwards, Hist. d. Crust. Pl. III. fig. 4, 1; and Carus, loc. cit. Taf. III. fig. 5, b. (Mata).


15 The internal female genital organs of the *crawfisht* are represented in Rosel, loc. cit. Taf. IX. fig. 24, 25; in Sackow, loc. cit. Taf. X. fig. 16; and in Brandt and Rotzeberg's Medic. Zoölog. Taf. XI. fig. 15.

16 The two vulvas of the *crawfish may be seen in the figures already cited. For those of the Anomura, which, except with *Pagurus*, are covered by the tail curved in front; see Milne Edwards, Hist. d. Crust. III. p. 172, Pl. X.XI. fig. 9, 18 (Dromia and Remipes), and Arch. du Mus. 1. Pl. XXVI. fig. 1, c. (Litóde). But the Caligidae form an exception in this respect,—their female genital openings being situated in the same places as those of the males, that is on the external side of the coxae of the posterior feet; see Krueger, loc. cit. p. 27, fig. 54, A. F. and fig. 67, b. g. (Hippolyte).

17 With *Pagurus*, the anal feet are developed only on one side of the tail.

18 Many erroneous opinions have been entertained by Zoologista on the subject of the female genital organs of the Chilognatha. Thus, *Treviranus* (Cerc. Schrift. II. p. 45) with *Julus*, and Brandt (Müller's Arch. 1837, p. 329, Taf. XII. fig. 8) with Glomeris, think they have observed double ovaries, as is also true of Stein (Müller's Arch. 1842, p. 246, 248); but Newport (Phil. Trans. 1842, p. 99; at in Fraser's nice Not. XXI. p. 161; see also, Rümmer Janer, Cyclon, loc. cit. p. 622, fig. 315, 316) has noticed only a single ovarian tube with *Julus*, which I have been able to confirm in the figures already cited. and for Glomeris, Brandt (ibid.), loc. cit. p. 157) has himself recently perceived the same.
Chilopoda, also, the ovary is a single long tube, but extends from before backwards and terminates by a short oviduct in the last segment of the body. The Receptaculum seminis consists, here, of two ovoid capsules, sessile or pedunculated, and inserted, upon the sides of the extremity of the oviduct. Into this last, moreover, just before its termination, long excretory ducts enter from the two to four Glandulae sebaceae, which furnish probably the viscous coating of the eggs.¹⁹

There has been the same misapprehension and changing of opinion on the subject of the position of the external genital openings. According to Treieranus, and Brandt (loc. cit.), they should be situated, with Julius and Glomeris, at the posterior extremity of the body; but Latreille (Hist. Nat. d. France, 1802, p. 385) had before indicated their true position with Polydesmus, and Nodi (Ibis, 1825, p. 217) has confirmed this with Julius. Brandt (Recueil, loc. cit. p. 154) has since rectified his error in respect to Glomeris. But Stein has treated with most detail the subject of the genital openings with Julius and Glomeris, as well as their seminal receptacles (Muller's Arch, 1842, p. 246, Taf. XII. fig. 12, and Taf. XIII. fig. 15. See also, my observations, Ibis, 1843, p. 9).

¹⁹ For the female genital organs of Lithobius and Scutigerina, see L. Desfour (loc. cit. p. 89, Pl. V. fig. 1, 4) who regards the two stalkless Receptaculum seminis of Lithobius as a reservoir of the four Glandulae sebaceae, and with Scutigerina, as the Glandes sebaceae themselves. I cannot now say whether these last organs are wanting in Scu- tigera, or whether they escaped the attention of this naturalist. Treieranus (Vers. Schrift. II. p. 25, Taf. V. fig. 8) has very well observed the simple ovary with its appendages of Lithobius; but he did not recognize the use of these last. Kuroser (loc. cit. p. 8, Tab. I. fig. 5) has not been more fortunate with the female genital organs of Scolopendra. These of Scolopendra morrisonis represented by Muller (Ibis, 1829, p. 550, Taf. II. fig. 5) are probably the male organs. Stein (loc. cit. p. 259, Taf. XII. fig. 2, 8) has described very accurately these organs with Lithobius, and Geo- philus. This last has two long-pedunculated seminal receptacles, and only two very long Glandulae sebaceae.

III. Male Crustacea.

§ 293.

The males of the Siphonostoma often differ very much from the females, not only as to their external form, but also in their smaller size,—their development being arrested at a very early period. On this account, some are still unknown, and the organization of others is not understood.¹⁵

With the Caligina, however, they have received more attention, for in size they are scarcely smaller than the females. Their posterior abdominal segment, which, usually, is not as large as that of the other sex, has, at its extremity, two genital openings, side by side. No testicles or excretory canals have yet been observed, but it may be inferred that their external form and their disposition are analogous to those of the oviducts.¹⁵

But with Dicellestium, the male organs are better known. The two spheroidal testicles, and the somewhat tortuous Vasa deferentia of these length of the thorax into the abdomen where it passes into the seminal organs. Described more particularly, the testicles are rather larger than the buccal mass, and are situated just anterior to the stomach, in part beneath the base of the prothoracic legs, and the spine of the preceding pair. — Ed.
Crustacea completely resemble, as to form and situation, the ovaries and oviducts of the females, except that the deferent canals are dilated, before their termination, into two seminal vesicles. (6)

With Argulus, the males have, at the base of their last pair of feet, a hook which is used in copulation. But as to their internal organs, there are, as yet, no credible observations. (4)

With the Cyclopidae, the male organs consist of a single pyriform testicle, the Vas deferens of which curves, first forwards, then backwards, and opens at the base of the tail on the median line. In the lower end of this canal, a homogeneous, cylindrical envelope is formed around the sperm, — a real spermaphore, which has a narrow neck, and which the males glue to the vulva of the females. (5)

For effecting this last, the males have one or even both of their antennae incrassated at their base, and provided with a special article near their extremity, which gives these organs a forficulate character. (6) When the male, by the aid of these antennae, has embraced the abdomen of the female, he bends the posterior part of his body forwards, and seizes hold of the female a second time with the forficulate foot of the second pair, at the same time grasping, with the other and digitiform foot, the spermaphore as it is escaping from the genital opening, and attaches it to the vulva. (7)

As yet we possess only quite incomplete observations upon the males of Daphnioidae, Cypridoidae, and Apodidae, which are found only at certain seasons of the year. (6) With the species yet observed, the testicles

3 Rathké, Nor. Act. Nat. Cur. XIX. p. 149, Tab. XVII. fig. 17. I do not know how it is with the males of the other Argasina, for as yet we know only the females of these animals.

4 Jurine, who was the first to notice these copulatory organs of the male Argulus, says he perceived at the base of the penultimate pair of feet a vesicular swelling containing, he thinks, a fecundating liquid (Ann. du Mus. loc. cit. p. 448, PI. XXVIII. fig. 1, 27). *

5 For the formation of these spermaphores with Cyclopsina castor, and minutus, see my Beitr. zur Naturg. d. wibelschen Thiere, p. 36, Taf. II. fig. 41-44, or Ann. d. Sc. Nat. XIV. 1840, p. 26, Pl. V. B. I have shown how their contents are thrust out in passing the neck by the action of a peculiar substance which swims when in contact with water.

6 The two antennae are thus endowed, with Cyclops quadririctus, Cyclopsina minutus, and alpestris; while this organization obtains with one antenna, only, with Cyclopsina castor, and Anomaloecra Patersoni; see the figures of Müller, Entomoostrac.; and Jurine, Hst. d. Monocles; also Vogt, Schweiz. Denksch. loc. cit. p. 18, Taf. II.; and Templeton, Trans. of the Entomol. Soc. II. p. 53, Pl. V. fig. 1, 5. The asymmetrical posterior pair of feet has been figured by Jurine, loc. cit. p. 61, Pl. IV. fig. 2, Pl. VI. fig. 11 (Cyclopsina castor), and by Templeton, loc. cit. p. 37, Pl. V. fig. 1, 18 (Anomaloecra).

7 These spermaphores, the true signification of which was unknown until lately, are found, often in the numbers of four to six, upon the same female, after several coitions occurring at different intervals; see Müller, loc. cit. Tab. XVI. fig. 5, 6, and Jurine, loc. cit. Pl. IV. fig. 6 (Cyclopsina castor); also Rammelk, loc. cit. Taf. III. fig. 6, 9, and Jurine, loc. cit. Pl. VII. fig. 2, 14 (Cyclopsina minutus). The spermaphores of this last have the form of a curved horn, and become, after a time, of a brown color. With Cyclops quadririctus, the sperm does not appear to contain spermaphores at the moment of its evacuation.

8 The males of Polyphemus, Limnadia, and Apus, have not yet been observed. It is said, it is true, that Koller (1854, p. 850) has discovered those of Apus cancriformis; but as yet nothing definite has been learned about the matter. At all events, the description given by Zollig (loc. cit. p. 53, Taf. 1. fig. 15, 16, and Taf. II. fig. 1, 2) of the male genital organs of these Crustacea, is unsatisfactory, for, at the point, where, according to this naturalist, are found the two male genital orifices surrounded by short spines, that is, on the dorsal surface of the last segment of the body, are found, with all the females also, similar orifices. It is therefore probable that the ramosce testicles which

coming from an accessory gland, which is pouch-like, and stretches back of the seminal vesicle. As auxiliary copulatory organs may be regarded a hook situated on the anterior border of each of the last pair of feet, and a node or papilla in the posterior border of the penultimate pair, corresponding, oppositely, with the hook. These hooks were taken by Jurine for penises, and the papil- lae for seminal capsules.— Ed.
consist of two spheroidal bodies which open externally, by two deferent canals, in front of the tail. (9) The copulatory organs are attached to the anterior feet, and consist of hooks and long bristles, by which these animals adhere to the under surface of the thorax of the females. (10) With the Branchiopoda, the male genital organs have a very remarkable organization. The testicles consist of two long, straight, caecal tubes, stretching the whole length of the tail. From the upper and dilated extremity of each passes off, inwards and backwards, an excretory canal. These canals, shortly after their origin, dilate into a seminal vesicle, and then pursue their course between two longitudinal ridges which run backwards from the base of the tail. At the posterior extremity of these ridges, they open near a process covered with short spines. For the seizure and retention of the females for copulation, the two anterior cheliform feet are provided with antler-like hooks, and, also, at their base, with two peculiar, sometimes digitiform processes, curved above the front. (11)

With the Pocillopoda, the testicles consist of ramified canals situated in the cephalothorax, which terminate at that same point on the first pair of post-abdominal feet where are situated the genital openings with the females, in two short, perforated, penis-like organs. (12)

With the Lacnomidipoda, Isopoda, and Amphipoda, the testicles consist of two caeca situated by the side of the digestive canal, and continuous, posteriorly, into two more or less flexuous deferent canals upon the sides of

* [§ 293, note 8.] For the genital organs of Cypris, see Zetler (Müller's Arch. 1856, p. 191). They closely resemble those of Cyclops. He has also described the spermatozoa (Taf. V. fig. 6); they are probably the very large spermatic particles seen by Wagner as mentioned above. These observations I have recently confirmed. Wagner and Leuckart (Cyclop. Anat. and Phy s i o l. Art. Sem en, p. 469, note) must, therefore, be mistaken, when they assert the hermaphroditic nature of Cypris, and say, "We beg to direct the attention to the simultaneous appearance of egg together with the spermatozoon in the same individual; and therefore to the hermaphroditic condition of the genitals in Cypris." It is probable that they observed only females, and if what they called such organs were really spermatic particles, the time of observation must have been soon after copulation. — Ed.

(11) For the details of the male genital organs of Artemia and Branchipus, see Leydig (loc. cit. Siboliff and Kulikoff's Zeits. III. p. 297). With these Phyllopods, these organs consist of testes, vasa deferentia, and penises; all of which are double and symmetrical. The testes consist, each, of an oblong pouch which is directly continuous into its vas deferens; and this last passes into its penis. The two penises are situated at the base of the abdomen, and point, bung-shaped, backwards. Besides these parts, there is an external organ, style-like, used in copulation (loc. cit. Taf. VIII. fig. 4, s.). — Ed.

Zaddach thinks he has observed with a small num ber of individuals which had been preserved in alco hol a long time, are only ovaries, the characteristics of which have been effaced by the spirit. As to Cypris, all we know about their males is that their spermatic particles, according to Wagner (loc. cit.), are disproportionately large, and that Ledermüller (Mémoires de l'Acad. Imp. Sci.) thinks he has seen them in copulation. Baird, also (Magna. of Zool. and Bot. I. p. 522), has often seen two individuals of Cypris together, but was not sure that they were copulating.

9 Locén, in Wiegmann's Arch. p. 169, Taf. V. fig. 13 (Crux.)
10 With the males of Daphnia, there is a hook together with a small long mass on the two anterior pairs of feet situated close under the head. The first pair of feet situated on the back in front of the mouth, is very long and provided with two small pointed hooks; while, with the females, these feet have the form of two short, obtuse antennae (Müller, Zoolog. p. 87, Tab. XII. fig. 6; Randorff, loc. cit. p. 25, Tab. VII.; Straus, Mem. du Mus. V. p. 419, Tab. XXIX. fig. 18, 19; and Jurine, Hist. des Monocles, p. 168, Pl. XI. fig. 3–8). With the males of Eudosina, only the feet of the first abdominal pair are provided each with a hook and some pretty long bristles on their last two articles (Locén, loc. cit. p. 157, Taf. V. fig. 11). With Isaura, on the other hand, the first two pairs of abdominal feet are armed at their extremity with stout nails (Strass, Mus. Suec. Hæm. II. p. 123, Taf. VII. fig. 4, 13; and Joly, loc. cit. p. 298, Pl. VII. fig. 2, 6).

11 Schaeffer, Dor fischförm. Kleinenz. fig. 2–11, and Müller, Zool. dänic. Tab. XLVIII. (Branchipus.) The frontal digitiform processes are especially developed with Chirocephalus; see Preuast, in Jurine's Hist. d. Monoc. p. 202, Pl. XXII. 12 Van der Horven, loc. cit. p. 29, Pl. II. fig. 14, 18 (Liminus).
which, with the Idoteoidae, and Asellina, are two pairs of similar seminal tubes. The two Vasa deferentia converge towards the posterior portion of the body, where they pass into a double, or a single excretory canal, which usually commences directly in front of the first pair of post-abdominal feet, on the median line of the body. With the Isopoda, this excretory canal opens into a short, backwardly-curved penis, upon which are two long processes (secondary penises) inserted on the internal border of the second pair of feet.

With the Stomatopoda, the testicles consist of more or less ramified, glandular lobes, from which pass off, laterally, two Vasa deferentia which terminate in two hollow penises projecting at the base of the last pair of feet.

With the Brachyura, and the short-tailed Anomura, the two testicles consist of a net-work of very small seminiferous canals, occupying the lateral portions of the cephalothorax, which gradually increase in size until they pass into the long Vasa deferentia. These last form numerous convolutions, and are finally continuous into two larger Ductus ejaculatorii.

With the male Paguridae, the testicles are contained, like the ovaries, in the tail. They consist of two large tubes which rapidly contract into a Vasa deferens, which is straight, at first, but afterwards spiral. This then becomes larger and is gradually continuous into a Ductus ejaculatorius.

With some Macrura, the cephalothorax contains two anterior and two posterior testicular tubes, a portion of the last being extended even into the tail; while the first are connected, by a transverse anastomosis, behind the middle of the body. The two posterior join with the two anterior in the posterior extremity of the cephalothorax, and form on each side, a short, narrow, deferent canal, which terminates in a larger Ductus ejaculatorius.
With other Macrura, the testicles consist only of a trilobed glandular mass covering the pyloric portion of the stomach, and from which pass off two long, very flexuous Vasa deferentia, which are dilated, near their extremity, into a nearly straight Ductus ejaculatorius. The excretory ducts of the sperm are very distinct with the Decapoda, when filled with this fluid, from their chalk-white color. With many species, the sperm, as it approaches the end of these ducts, is divided into portions, around which capsules or spermato- 

These last are usually pyriform, and connected together by a common band. The external genital organs of the male Decapoda are quite varied, although these excretory ducts almost invariably open on the coxal joint of the last pair of feet. With the Paguridae, and Macrura, the male genital orifices are surrounded by a soft spherimeter, without any trace of a penis, but out of which the Ductus ejaculatorius is perhaps protruded during copulation. But with the Brachyura and short-tailed Anomura, on the contrary, there are two longer or shorter tubular penises, always covered by the tail, which is pressed against the belly. With very many Decapoda, the two feet of the first caudal segment are transformed into pedicellated processes (secondary penises), the extremity of which is sometimes grooved. With some short-tailed Anomura, the feet of the second post-abdominal pair take part also in the act of copulation, and, for this purpose, are prolonged into stalk-like organs.

Among the Myriapoda, the Glomerina have two testicular tubes extending into the abdomen and composed of numerous vesicles partially blended together. They unite in the thorax into a common Vas deferens. With the Julidae, the testicles have a similar structure, but the vesicles open separately into the external side of the two Vasa deferentia, which are close together, and are connected, in a ladder-like manner, by numerous trans-

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10 With Astacus; see Roesel, loc. cit. Taf. LVIII. fig. 9, and Taf. LX. fig. 23; Suckow, loc. cit. Taf. X. fig. 15; Brandt, Mediz. Zool. II. Taf. XI. fig. 34; Milne Edwards, Hist. d. Crust. Pl. XII. fig. 14; and Carus, Erlauterungstaf. Heft V. Taf. III. fig. 9.

11 These spermatophores, first made known by Küttiker, are bound together, with Gutalthea, by ramified pedicles; and with Pagurus, by simple filaments; see Küttiker, Beitr. zur Kenntniss d. Geschlechts, &c. p. 9, fig. 21, 22, also, Schweizer. Denksch. VIII. p. 52, fig. 32-35. See also, the description which I have given of the spermatophores of Pagurus helenardus, in Müller's Arch. 1842, p. 136, note 1. But one must be careful not to take, in the testicles of the Decapoda, the mother-cells in which are developed the会产生 cells for the spermatophores.

12 The hair crabs make an exception in this respect, their male genital orifices being situated on the last segment of the body; see Milne Edwards, Hist. Nat. d. Crust. I. p. 168, Pl. XVIII. fig. 6 (Gecarcinurn).

13 For Astacus, see the figures cited above; for Palinurus, Milne Edwards, Hist. d. Crust. Pl. XXIII. fig. 2; and for Hippolyte, Kröger, loc. cit. p. 27, fig. 54, B. f.

14 There are two very short, and soft penises with Maia, Pisa, Cancer, Grapinus, Lepus, Gecarcinurus, Porcellana, Hornula. They are long, hard, and point forward with Dromia.

15 The cannulated, secondary penises may be very easily seen in the first caudal segment of Hornuana, Nephtrope, and Astacana: Roesel, loc. cit. Taf. LV. fig. 1; and Carus, Erlauterungstaf. Heft V. Taf. III. fig. 12 (Astacus). In this last genus, these organs are slightly spiral at their extremity. These penises are long, secondary, and connected under the tail with the male Brachyura and Anomura, with which the majority of the other and feet are wanting; see Milne Edwards, Hist. d. Crust. I. p. 169, Pl. III. fig. 6, 15, 16 (Maia); in this genus the two pairs of anal feet are rudimentary. This abortion is observed, also, with Grapinus, Cancer, Lepus, Grapinus, Porcellana, &c. See the beautiful figures of Scyllaridae, in Descrip. de l'Égypte, Crust. Pl. II.-VI., and Cuvol. loc. cit. Taf. XI. fig. 10 (Grapinus). With Dromia, the two feet of the second caudal segment have the form of two long spines. With Hornuana, the same feet are equally pedicellated, but terminate with a kind of sucker, and, therefore, are undoubtedly auxiliary in the act of copulation. No auxiliary organs have been found with Gutalthea, Palinurus, and Scyllaridae; but in the last two of these genera the feet of the first caudal segment are wholly wanting. With the Caridolidae, the copulatory organs are usually absent, and the first pair of anal feet does not differ from those above; with Carangon, only, have I found the internal prolongation of these feet highly developed and gla-

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verse anastomoses. In front, the testicular vesicles are lost in these canals, which finally diverge from each other in an arcuate manner, as is also true of the "Vas deferens of the Glomerina. In this manner, these canals, as two Ductus ejaculatorii, extend to a triangular scale situated under the third thoracic segment, and terminate at the lower angles of this scale in two short, conical, penis-like protuberances.29

With the Chilopoda, the male organs are very complicated and formed upon a wholly different type. Their orifices are always situated at the posterior extremity of the abdomen. With some species, there is only a single, long, testicular tube into which pass two lateral, also very long, coecal tubes (Epideridymes?). At their point of junction, arise two short Vasa deferentia, which terminate in a common, short, campanulate penis. Other Chilopoda have two to three varicose testicular tubes which anastomose, loop-like, at both of their extremities, and terminate, at last, in a longer or shorter Vas deferens, which bifurcates in its course, but its branches come together again in a short penis. With all the Chilopoda, the common genital orifice is connected with the short excretory ducts of two to four oblong accessory glands, the nature of which is yet unknown.29

§ 294.

The Development of the Crustacea occurs, as with all Arthropoda, according to a special type.1

After the disappearance of the germinative vesicle, a partial segmentation occurs upon a given point of the surface of the vitellus. By this process, a transparent, finely-granular, proberilis disc is formed.2 The borders of this disc gradually extend over, and finally cover the surface of the vitellus. It is then changed into a proberilis vesicle enclosing the remainder of the vitellus.

At the pole of the egg where the proberilis disc is first formed, are de-

25 For the male organs of the Chilognatha, see Newport, Philos. Trans. 1842, loc. cit. p. 90; Hymer Jones, Cyclops (III.) p. 553, fig. 314; and Stein, in Müller's Arch. 1842, p. 246, Taf. XII.-XIV. (Julus, Polydysmus, and Glomeris). The two testicles of Glomeris were formerly described as ovaries by Brandt; see his Beitr. loc. cit. p. 325, Taf. XII. fig. 8; but he has rectified this in his Recueil, loc. cit. p. 157. For the copulatory organs of the Jubalae, may be cited, also, the researches of Lalitreille, and Saci (loc. cit.).

26 Lithobius has only a single testicular tube with two epididymes and four accessory glands (Treviranus, Verm. Schrift. II. p. 23, Taf. V. fig. 7; L. Doufurr, loc. cit. p. 57, Pl. V. fig. 2, 3, and Stein, loc. cit. p. 240, Taf. XII. fig. 1). Gracihis has three interanastomosing, varicose, and two accessory glands (Stein, loc. cit. p. 285, Taf. XII. fig. 7). Judging from Müller's figure (loc. cit. Taf. II. fig. 5), Scolopendra maritima has also two anastomosing varicose testicles. But this point is made somewhat uncertain from the researches of Kowrona (loc. cit. p. 10, Taf. II. fig. 4-6), who has shown positively the existence of four accessory glands with this animal. L. Doufour's figures (loc. cit. p. 57, Pl. V. fig. 5) of the male organs of Scoligera indicate here a very different organization. There are two testicular tubes which unite laterally, like the anterior extremity and then send off a long very flexible canal which has two pedunculated vesicles (Vesiculae seminales). The posterior extremity of these testicles is continuous into two Vasa deferentia which become dilated into as many Ductus ejaculatorii. Perhaps this abnormal organization of these animals in this respect, will be reduced from further researches to the type of the Scolopendra.


2 Caeor marinus forms perhaps the only exception in this respect. Here, the segmentation appears to be complete; see Rathke, in Fabricie's neue Not. loc. cit. p. 182; and Erdi, loc. cit. p. 27.
veloped the ventral portion together with the abdominal cord of the future embryo; while, at the opposite pole, where the borders of the disc meet, the dorsal portion of the animal appears. Quite early, the blastoderms can be seen composed of an external or serous, and of an internal or mucous layer. This last, after having enveloped the entire vitellus, is changed gradually into the alimentary canal. The hepatic organs are only devere-
culi of this last, while the antennae, the oral apparatus, the feet, and the branchiae, are developed from the serous layer.

The embryos, thus formed, differ considerably, and their form is often so dissimilar from that of the adult animal, that, during their ulterior development, there is a real metamorphosis, which takes place by more or less numerous stages coincident with the act of moulting.

An embryonic type quite general among the lower Crustacea, that is, the Cirripedia, Siphonostoma, Lophyropoda and Phyllopoda, is that which was first observed with Cyclops. There is here a long series of metamorphoses. The monocle larvae have an ovoid, unarticulated body, usually provided with a single, simple eye, and two or three pairs of car-like appendages covered with long hairs. With some Brachyura, there is an equally well-marked metamorphosis: for, in leaving the egg, they have a long tail and two very large eyes; but with the first moulting they acquire two enormous, spur-like apophyses, one on the front, and the other on the back.

It is remarkable that the young Cirripedia, which are hexapod, have the characteristics of the larvae of Monocles; see Thompson. Zool. Research. loc. cit. p. 69, Pl. IX. (Balanus); Bur- meister, Beitr. loc. cit. p. 12, Taf. I. (Lepas); Goodrich, Edinb. New Philos. Journ. No. 56, July, 1845, p. 97, Pl. III. IV., or Isis, 1844, p. 891, Taf. I. figs. 8, 11-17 (Balanus). Tlie larvae of these Cirripedia, before becoming fixed in order to undergo their metamorphoses, change into a bivalve animal resembling Cypria. Among the Siphonostoma, the monocle embryos are very general. Nordmann (loc. cit. p. 11, &c., Taf. II.-VII.) has recognized larvae of this kind, some with three (Ergasilus and Lernaeocera), and others with only two (Achtheres and Trachelostom) pairs of feet. According to Kollar (loc. cit. p. 87, Taf. X. fig. 10), the embryos of Basonistes are monocle-like and have six feet, as are also those of Lernaeopoda described by Rathke (Zur Morph. loc. cit. p. 54, Taf. 1). Goodrich (loc. cit. No. 66, July, 1845, p. 178, Pl. III. fig. 19-23) has observed embryos with four feet in the eggs of Culticus. The larvae of Nicobas (Rathke, Nov. Act. Nat. Cor. XX. p. 103, Taf. V. fig. 8-10) and of Argulus (Müller, Entomosmin. p. 122, Tab. XX. fig. 2, and Jurine, loc. cit. p. 453, Pl. XXVI. fig. 4) form an exception in this respect, for when they leave the egg they have two simple eyes, an

6 It is remarkable that the young Cirripedia, which are hexapod, have the characteristics of the larvae of Monocles; see Thompson, Zool. Research. loc. cit. p. 69, Pl. IX. (Balanus); Burmeister, Beitr. loc. cit. p. 12, Taf. I. (Lepas); Goodrich, Edinb. New Philos. Journ. No. 56, July, 1845, p. 97, Pl. III. IV., or Isis, 1844, p. 891, Taf. I. figs. 8, 11-17 (Balanus). The larvae of these Cirripedia, before becoming fixed in order to undergo their metamorphoses, change into a bivalve animal resembling Cypria. Among the Siphonostoma, the monocle embryos are very general. Nordmann (loc. cit. p. 11, &c., Taf. II.-VII.) has recognized larvae of this kind, some with three (Ergasilus and Lernaeocera), and others with only two (Achtheres and Trachelostom) pairs of feet. According to Kollar (loc. cit. p. 87, Taf. X. fig. 10), the embryos of Basonistes are monocle-like and have six feet, as are also those of Lernaeopoda described by Rathke (Zur Morph. loc. cit. p. 54, Taf. 1). Goodrich (loc. cit. No. 66, July, 1845, p. 178, Pl. III. fig. 19-23) has observed embryos with four feet in the eggs of Culticus. The larvae of Nicobas (Rathke, Nov. Act. Nat. Cor. XX. p. 103, Taf. V. fig. 8-10) and of Argulus (Müller, Entomosmin. p. 122, Tab. XX. fig. 2, and Jurine, loc. cit. p. 453, Pl. XXVI. fig. 4) form an exception in this respect, for when they leave the egg they have two simple eyes, an

9 For many highly-interesting details on the economy of the Entomostraca, see Baird (British Entomosmin. &c., loc. cit. passim). These details with their corresponding figures will render clear many obscure economical points alluded to above. For the embryology of Argulus, Artemia and Branchipus, see Leydig, loc. cit. Siebold und Kükner's Zeitschrift, II. p. 344, and III. p. 504. The descriptions of this observer are quite rich in details upon the successive appear-

ances of the different organs. Argulus is quite well developed when hatched, its muscles are transversely striated and the locomotory organs well formed. Artemia has, at this period, two antennae, two pairs of feet on the head, and the red pigment spots on the forehead, but these last have as yet no light-refracting body. The muscles are still without stripe, and even here and there are filled with vitelline globules. The heart and blood-cir-

ulation are still unformed. — Eo.
names Megalopa, Monopleis and Zaena (Milne Edwards, Hist. d. Crust. II. p. 260, 431), until Thompson perceived their true nature; see his Zool. Research. &c. Pl. I. and his Mem. on the double Metamorphosis in the Decapodous Crustacea, in the Philos. Trans. 1835, pt. II. p. 539; see also the Edinb. New Philos. Journ. No. 20, p. 221, and the Entomol. Magaz. No. 14, p. 270. Although these observations have been confirmed from different sides, yet they did not, at first, receive full assent, especially on account of the authority of Rathke (Muller's Arch. 1836, p. 187), who opposed them. Templeton (Trans. of the Entomol. Soc. II. p. 115, Pl. XL) and Westwood (Philos. Trans. 1835, pt. II. p. 311, Pl. IV) refuse to give up the genus Zaena; but since Du Cane (Ann. of Nat. Hist. III. 1839, p. 468, Pl. XI. or Friepe's neue Notiz. XIII. p. 5, fig. 10-15), has verified, with Cancer maenas, the observations of Thompson, and Rathke himself (Wiegmann's Arch. 1840, I. p. 246, and Neuest. Dandiz. Schrift. loc. cit. p. 30, Tab. IV), has seen the embryos of Hya under the form of a Zaena, this wonderful metamorphosis of the Brachyura can no longer be doubted. See also Steinstr., in the Oversigt over det kgl. danske Videnskabernes Selskabs Forhandlinger, 1840, p. 15, or Muller's Arch. 1841, p. 218 (Hya), and Goodsir, Edinb. New Philos. Journ. No. 65, 1842, p. 181, Pl. III. fig. 16-18 (Cancer maenas).

3 The embryos of Pagurus which have a frontal spine, were also, before the discovery of Thompson, taken for species of Zaena; see Philipp, in Wiegmann's Arch. 1840, I. p. 184, Tab. III. fig. 7, 8; also Rathke, Ibid. p. 242, and, Dandiz. Schrift. loc. cit. p. 29, Tab. III. 1841, Steinstr., loc. cit.; and Goodsir, loc. cit. No. 65, p. 182, Pl. III. fig. 12-14. The difference in form between the embryos and the adults is less marked with Astacus, Homarus and other Maeridae; see Rathke, Estwick, &c. in the Danzig. Schrift. loc. cit. p. 25, Tab. II. Homarus); Du Cane, Ann. of Nat. Hist. III. 1839, p. 175, Pl. VI. VII. or Friepe's neue Notiz. XIII. p. 5, fig. 4-8 (Palaeomon and Crangon); Kroeger, Monogr. loc. cit. p. 37, Pl. VI. (Holopluteus and Homarus); Joly, Ann. d. Sc. Nat. XIX. loc. cit. Pl. IV. (Cardinale), and Erdi, loc. cit. p. 18, Tab. III. IV. (Homarus).

4 According to Milne Edwards (Notiz. 1828, No. 255, p. 357), a cephalothorax and abdomen may already be distinguished with the hatching embryo of Limulus. But the abdomen has only three pairs of appendages and its long spine is wholly wanting. This naturalist, also, has figured an embryo of Gymnus which closely resembles the adult (Ann. d. Sc. Nat. III. 1835, p. 228, Pl. XIV. fig. 14).


The young of the Paguridae and Macrura differ more or less from the adult animals. But this difference is less with the Pocelopoda, Laemodiopoda, Stomapoda, Isopoda, and Amphipoda. Finally, with the Myriapoda, the metamorphosis is limited to the increase of the number of the segments of the body, and of the feet.
The Arachnoidae, which are organized after very different types, have always four pairs of feet. The Tardigrada form no exception in this respect; and although it may appear singular to find them placed in this class, yet this seems their most proper place; only they should be placed at the head, for they form the transition of the Arachnoidae to the Annelides, exactly as do the Cirripedia from the Crustacea to the Acephala.*

The Arachnoidae are usually defined as Arthropoda wanting the antennae; this, however, is incorrect, for these organs are not wanting, strictly speaking, but take the place of the mandibles, which are absent, as will be shown hereafter.

**ORDER I.**

Cephalothorax multi-articulate. Special respiratory organs wanting.

**SUB-ORDER I. TARDIGRADA.**

Legs rudimentary. Abdomen wanting.

Genera: *Milnesium, Macrobiotus, Emydium.*

**SUB-ORDER II. PYCNOGONIDAE.**

Legs very much developed. Abdomen rudimentary.

Genera: *Nymphon, Ammoothea, Pallene, Phoächichilidium, Pariboea, Endeis, Pheoächichilus, Pycnogonum.*

* [§ 295.] For a detail of the data which fully justify this position of the Tardigrada, see *Kaufmann, Ueber die Entwicklung und systematische Stellung der Tardigraden,* in *Siebold and Köllicher’s Zeitsch.* III. 1851, p. 220. — Ed.
ORDER II.

Cephalothorax unarticulated, or biarticulated. Respiratory organs consisting of tracheae.

SUB-ORDER III. ACARINA.

Abdomen unarticulated and fused with the cephalothorax. Palpi simple.

Family: Acarina.

Genera: Demodex, Sarcoptes, Glycyphagus, Tyroglyphus, Melichares, Dermaleichus, Acarus, Pterooptus.

Family: Hydrachnea.

Genera: Limnochares, Arrenurus, Eylaës, Diplodontus, Hydrachna, Atax.

Family: Oribatea.

Genera: Hoplophora, Oribates, Zetes, Pelops, Damaeus.

Family: Gamasea.

Genera: Dermanyssus, Uropoda, Gamasus, Argas.

Family: Ixodea.

Genus: Lcodes.

Family: Bdellea.

Genera: Bdella, Molgus.

Family: Trombigna.


SUB-ORDER IV. OPILIONINA.

Abdomen articulated, but indistinctly separated from the cephalothorax. Palpi simple.

Genera: Phalangium, Gonyleptes, Eusarcus.

SUB-ORDER V. PSEUDOSCORPII.

Abdomen articulated, but indistinctly separated from the cephalothorax. Palpi forficulate.

Genera: Obisium, Chelifer.

SUB-ORDER VI. SOLPUGIDAE.

Abdomen articulated, distinctly separated from the cephalothorax. Palpi simple.

Genus: Galeodes.
ORDER III.
Abdomen and cephalothorax unarticulated, distinct from each other. Respiratory organs consisting of tracheae and lungs.

SUB-ORDER VII. ARANEAE.

ORDER IV.
Abdomen articulated. Cephalothorax unarticulated. Respiratory organs consisting only of lungs.

SUB-ORDER VIII. PHYRNIIDAE.
Abdomen distinct from the cephalothorax. Cheliceres unguiculate.
Genera: Thelyphonus, Phrynus.

SUB-ORDER IX. SCORPIONIDAE.
Abdomen indistinctly separated from the cephalothorax. Cheliceres forficulate.
Genera: Scorpio, Bathus, Androctonus.

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CHAPTER I.

EXTERNAL ENVELOPE AND CUTANEOUS SKELETON.

§ 296.

The external envelope of the Arachnoidae is usually soft, or coriaceous, rarely horny; but in no instance does it possess a proper contractility. In place of this, however, it is extensible in the highest degree with many species. This extensibility is seen especially with those species which are accustomed to long fasts, having only an occasional opportunity to fill their digestive canal with food consisting of the animal juices.

The envelope is composed here, as with all the Arthropoda, chiefly of chitine. To this last are undoubtedly due its solidity and indestructibility, which may be observed with the small and delicate Acara and Tardigrada, not only when it is in a fresh state, but even after it has been cast off by a kind of moulting.

§ 297.

With most Arachnoidae, the cutaneous envelope may be separated into two tunics; an external and an internal. The first is the more solid and thick, and, in the cephalothorax and the extremities, has often a cellular structure. Upon the abdomen of the Araneae and Aecaria, it presents peculiar, waving markings which, as concentric rings, surround the base of the hairs; but it is difficult to determine if they are due to delicate plicae, or the effect of the intimate structure of the skin. With Lyodes, only, these prominent lines appear, unmistakably, as folds of the epidermis, for they completely disappear when these animals are gorged with food.

The epidermis is often provided with papillae, clavate excesences, spines, bristles, simple or plumose hairs, and even, sometimes, with scales. These various cutaneous formations, which are usually hollow, either occupy only certain points, or are extended over the whole surface of the body, giving it a velvety or a furry aspect.

The internal tunic of the skin consists of a thin, always colorless membrane, finely granular or fibrillated, which is perforated at those points where there are hair-like or other formations of the epidermis. Directly beneath this membrane, which, undoubtedly, reproduces the epidermis after

1 For example, with Scorpions and Phrynidae. The cutaneous envelope is hardest and most fragile with the Orbatæ, where it breaks like glass from the slightest pressure.
2 For example, with Leodes, and Argas, as also with the parasitic larvae of certain Hydrachnae and Tremblidæ, known under the names of Schlytina and Leptus.
4 This solidity of the skin with the Tardigrada, is one evidence that these animals are more properly classed with the Arachnoidæ, instead of with the worms whose skin contains no chitine and is, therefore, quickly dissolved in caustic potash. See the analyses of the skin of the earth-worm by Las-
§ 298.

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moulting, is a layer of colored vesicles and granules, which can be seen through the skin, giving it the very often beautiful colors which are observed in many species.

The various divisions of the cutaneous skeleton, of which the number is quite limited, have been so thoroughly studied in zoology, that they may well be passed over here without notice.

The Cephalothorax sends off from its inner surface, especially with the Opilionina, and Araneae, various processes, which serve, as with the Crustacea, as points for the insertion of muscles, and as septa between certain organs. With the Araneae, they form, at the bottom of the cephalothorax, a solid horizontal plate,—a kind of internal skeleton, which, before and behind, is attached to the sternum by two tendinous ligaments. This plate is deeply indented on its anterior border, and furnishes points of insertion for the muscles of the extremities, as well as for several other parts. 4

CHAPTER II.

MUSCULAR SYSTEM AND ORGANS OF LOCOMOTION.

§ 298.

The voluntary muscles of the Arachnoidae are of a dirty-yellow color, and, like those of the Crustacea, are distinctly striated transversely. 5 Their general disposition agrees, also, with those of Crustacea. 6

The principal muscular masses are found in the cephalothorax, for here arise, not only the muscles of the parts of the mouth, but also those of the first article of the tactile organs and legs. With those species having an unarticulated abdomen, the muscles of this part of the body differ from those of Crustacea. For, directly beneath the skin, is a thin layer, composed of numerous short, ribbon-like fibres, interlaced in various directions, and frequently anastomosing with each other. 7 Moreover, with many species, there are, on both the dorsal and the ventral surface of the abdomen, depressions of the skin, from which pass off small muscular bands, which penetrate into the interior of the abdomen, and pass among the visceræ.

With the Araneae there is, generally, on each side of the ventral median

4 This plate, already recognized by Lyonet (loc. cit. p. 408, Pl. XXI. fig. 26), and by Treviranus (Bau d. Arach. Taf. II. fig. 25), has been described more exactly by Wasmann (loc. cit. p. 2, fig. 2–4). A similar, but rudimentary plate, exists, perhaps, with Phalangiæ, and, as it lies under the ventral cord, the muscles have the appearance of rising from this last; see Tulk, loc. cit. p. 525, or in Forjép’s neue Notiz. XXX. p. 196.

5 The Tardigrada form an exception in this respect, their muscles being smooth; see Doyère, loc. cit. p. 535.

6 For the disposition and arrangement of the muscular system of Scorpionidae and Araneae, see Meckel, Syst. d. vergleich. Anat. III. p. 47; and for the muscles of Phalangiæ and Mygalæ, see Tulk, and Wasmann, loc. cit. The very complicated muscular system of the Tardigrada is quite apparent from the transparency of these animals; see Doyère, loc. cit. p. 535, PI. XVII. –XIX.

7 This cutaneous layer, already observed by Treviranus (Verm. Schrif. I. p. 9, Taf. I. fig. 3, a. a.), and by Brandt (Moll. Zool. 1. p. 68, Taf. XV. fig. 3, a. a.), or Ann. d. Sc. Nat. XIII. p. 180, PI. IV. fig. 1, a. a.), with Epigera, has been confirmed by Tulk (loc. cit. p. 154) with Phalangiæ, and described in more detail by Wasmann (loc. cit. p. 8, fig. 7, 8) with Mygalæ.
line, a tendinous ligament, on which are inserted several of these muscular bands. It is very probable that these animals can, by this apparatus, compress their abdomen in various directions.

§ 299.

The locomotive organs of the Arachnidae are situated exclusively on the cephalothorax. They consist of only four pairs of legs, of which the first may, perhaps, be regarded as the posterior pair of metamorphosed maxillae.

Some Mites, only, when young, have six feet, and the young of the Pycnogonidae have, also, only four. With Phrynus, and Thelyphonus, the first pair considerably resembles two multi-articulated tactile organs; but with Galeodes, these same organs have wholly the appearance of legs, excepting they are without claws. With Mygale, the maxillae of the first pair have the form of feet, and their extremity is not only ungualculated, but also provided with a tarsus. The other Arachnidae have usually nails on all their feet, and, with some, each foot may have four nails. With many Araneae, the nails have, on their convex side, a pectinated appendage.

As to the types of the articulations of the legs, they are usually as follows; first, a movable Coxa; then a short Trochanter; then a longer, stiff Femur; then a Tibia, divided by an articulation into two unequal parts; and, finally, a Tarsus, composed of a short and a short article. With the Phrynidae, not only are the first and antenniform pair of feet already mentioned, different from this type, but the three other pairs have a great number of articles, each tarsus having four. But the Phalangidae differ the most,—the tarsi of all the feet having an extraordinary number of articles. On the other hand, among the lower Arachnidae, and especially with the Aracjina and Tardigrada, there are species with which the seven articles just mentioned cannot be easily distinguished, for the articulations are less in number, or wholly indistinct. With many of these species, some of the pairs of legs, or even all, are reduced to real foot-stumps. Numerous parasitic Aracjina have, between the nails, a small organ (Arolium), by which, as with a sucker, they can attach themselves to foreign bodies. These organs are most developed with Sarcopes and allied genera, which are without nails, for they here consist of a long, pedunculated disc upon all, or only upon some of the feet. With the aquatic Hydraenae, the swimming feet have no other peculiarities than that one of their sides is thickly pilose.

4 For these muscles, the cutaneous insertions of which, with the Araneae, with Chelifer and Pha-
langium, have been taken by Trechunus (Bau-
6 Most usually there are two nails to each foot; but Phalangium, Hoplopchora, and Damaeus, have only one; while Segestria, Luchestis, and Clotho, as well as Demodes, Pelops, Zetes, and Oribacut, have three, and Embydium and Macro-
bius have even four.
7 See the figures of Savigny, loc. cit.
8 The articulations are few and indistinct with all the eight legs of Tyrocluphus and Glyciphaga-
thus, but with the anterior legs, only, with Sarco-
pes. The posterior legs of this last genus, and all of them with the Tardigrada, and with Demodes
folliculorum, are only simple stumps.
9 For example, with Isodes, Argas, Demong-
sus, Pteronymus, &c.
10 With Sarcopes avis and cati, this alorum is absent with the penultimate pair of legs; and with Sarcopes equi, with the last pair. With Sar-
cope wynolouth, Glyciphagus prunorum, and Meli-
chares agilis, all the legs have long pedunculated organs of this kind; see Hering, Die Kristalliten
CHAPTER III.

NERVOUS SYSTEM.

§ 300.

The grades of development of the Nervous System with the Arachnoidae are very different, being connected with the divisions of the cutaneous skeleton. For, when these last disappear, those of the nervous system belonging to them, and often the ventral cord, are concentrated, as with the brachyurous Decapoda, into a single ganglionic mass, occupying the ventral portion of the cephalothorax; while, if the body is multi-articulate, this system resembles that of the macrurous Decapoda. In both cases, with only a few exceptions, there is a cerebral ganglion situated above the oesophagus, and connected with the ventral cord by two short commissures surrounding this canal. From this ganglion pass off nerves to the eyes, and the maxillary palpi or so-called mandibles; while the first pair of maxillae, changed into tactile organs, receive their nerves from the anterior extremity of the ventral cord.

The intimate structure of the nervous system, with the Arachnoidae, consists of primitive fibres much finer, and ganglionic globules much smaller, than those of Crustacea. As to the direction and disposition of these fibres, those of the Scorpionidae almost exactly resemble those of the Myriapoda.

§ 301.

The nervous system is most simple in its organization with the Acarina. In those species where, as yet, it has been found, it consists only of a simple abdominal ganglion, from which pass off, from all sides, the peripheral nerves; and, upon the upper surface of which, is detached a simple transverse band, under which the oesophagus passes. With the Tardigrada, this system is a little more developed, although the brain is still wanting. It consists of four ganglia, corresponding to the four segments of the body, and connected together by double longitudinal commissures. Between each of the ganglia, the commissures are connected by a transverse filament. The nerves which proceed from the ganglia belong to the muscles; but the first ganglion sends, moreover, in front, four larger trunks, which are the nerves of sense, and are distributed to the eyes and palpi.

1 Hannover, loc. cit. p. 71, Pl. VI. fig. 83, 84.
2 See § 271, and Newport, Philos. Trans. 1843, loc. cit.
3 With many small Acarina, particularly Sarcoptes and Demodex, no traces of a nervous system have been found, notwithstanding the most careful researches; but this is not surprising, considering the minuteness of these animals.
4 Tetranychus (Verm. Schrift. I. p. 47, fig. 32) has investigated the nervous system of Trombidium, and the results he obtained have been confirmed with this genus and with Larnnochares, by Dujardin (Ann. d. Sc. Nat. III. p. 19). Subsequently, Tetranychus (Zeitsch. f. Physiol. loc. cit. p. 189, Taf. XVI. fig. 7. c.) has also confirmed, with Loudex, this passage of the oesophagus through the principal ganglionic mass. With Trombidium, whose ganglion is somewhat reddish, the cerebral commissure is quite distinct.
5 See Doyere, loc. cit. p. 343, Pl. XVII. (Milnesium).
The ventral chain of the Pycnoognidae is composed likewise of four ganglia, but these, which send off, each, a nerve from its side to the corresponding foot, are contiguous, and the first connects with the ovoid cerebral ganglion by two lateral commissures.\(^1\)

With the Araneae, the central portion of the nervous system consists of a large sub-oesophageal ganglion, and another, smaller and above the oesophagus. \(^2\) They are separated from each other only by a narrow fissure through which the oesophagus passes. The super-oesophageal ganglion, which is somewhat emarginated in front, corresponds to the brain, and sends off nerves to the eyes and chelicerae. The sub-oesophageal ganglion, situated in the middle of the cephalothorax, sends off, on each side, four larger processes, from which arise the nerves of the feet. Its anterior border supplies, moreover, the nerves of the two palpi; and from its posterior margin pass off two nerves for the abdominal viscera.\(^3\)

The nervous system of \textit{Galeodes}, \(^6\) \textit{Phrynus}, and \textit{Thelyphonus},\(^5\) has a like disposition.

The central mass of the nervous system of the Phalangidae begins by two conical, contiguous cerebral ganglia, which connect with a sub-oesophageal, fused ganglion, by two short lateral commissures. This ventral ganglion is composed of a transverse portion, which is situated in the centre of the cephalothorax, and of two lateral portions which consist, each, of an anterior or larger, and a posterior or smaller lobe. These lobes send off nerves to the eight legs, and in front, others to the palpi; while from the posterior border of the transverse portion pass off several nerves to the viscera of the abdomen.\(^6\)

With the Scorpionidae, the nervous system is very highly developed. The brain, which is not large, is composed of two spheroidal, super-oesophageal ganglia fused together. Above, and in front, they send off nerves to the eyes and the chelicerae; and below, they connect with the first ventral ganglion by two short, large filaments, which embrace the oesophagus. The first ventral ganglion is pretty large, being the result, probably, of the fusion of several ganglia. It is situated in the middle of the cephalothorax, and sends nerves to the palpi and to the eight legs. In the rest of the body there are three ventral ganglia, smaller, and followed by four others situated in the tail. All these ganglia are connected by double, longitudinal commissures, and the posterior seven give off, from each side, two nerves; while from the last ganglion arise also two others, which, passing backwards, soon unite and extend to the very extremity of the tail, sending off nerves right and left.\(^7\)

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\(^1\) Quatrefages, loc. cit., 77, Pl. I. fig. 18 2; also Pl. II. fig. 2, 3 (Amoetother and Phoxichilitus).


This last author has represented, in a very instructive manner, the nervous system of a \textit{Mygale} seen in profile.

\(^3\) Blanchard, loc. cit. p. 1394.

\(^4\) \textit{Von der Hoeven}, Tijdschrift. loc. cit. IX. 1842, p. 68, and X. 1843, p. 599.

\(^5\) [\$ 301, note 9.] See also \textit{Dafour} (Ann. d. Sc. Nat. XV. 1851, p. 250). This anatomist has found a fourth abdominal ganglion, situated just behind the thoracic mass, from which pass off a pair of nerves to the pulmonary organs (\textit{Scorpio octonius}). — Ed.

\(^6\) The nervous system had already been partially described by \textit{Treviranus} (Vern. Schrift. I. p. 38, Taf. IV. fig. 24); but especially, and with full details, by \textit{Tulk}, loc. cit. p. 324, Pl. V. fig. 31.

\(^7\) For the nervous system of the Scorpionidae, see \textit{Treviranus} (Bau. d. Arach. p. 14, Taf. I. fig. 15, and Zeit. Physiol. IV. p. 59, Taf. VI. fig. 1-3, and \textit{Muller}, loc. cit. p. 66, Taf. I. fig. 5, 7); but especially \textit{Newport's} excellent description (\textit{Psilus}. Trans. 1843, p. 260, Pl. XII.) he has traced, with \textit{Audufoctonu}, the nerves of the extremities even into the tarsal articles and terminal hooks.
§ 302.

THE ARACHNOIDEA.

§ 302.

A Splanchnic nervous system has been observed with only the higher Arachnida; but here it is highly developed. The odd stomachic nerve has been the part most difficult to discover; it is observed, however, with some Araneae, — the posterior border of the brain sending off two small filaments which traverse the central opening of the stomach but unite on its dorsal surface. 1 The Scorpionidae have a similar stomachic nerve which also arises from the brain by two filaments which have a small ganglion at the point of their union. 2

With the Phalangidae, Araneae, Galeodea, and Phrynidae, the splanchnic nerves are very distinct. They arise from the posterior border of the ventral nervous mass situated in the cephalothorax, and are distributed to the digestive, respiratory, circulatory, and genital organs, and have, sometimes, ganglia on their course. With Phalangium, there are three of these nerves arising from the posterior border of the transverse portion of the ventral mass. The middle one of these nerves divides into two branches, which dilate into two ganglia connected together by a transverse anastomosis. From these two ganglia arises a nervous plexus, which is distributed to the internal genital organs, and to the corium. The lateral nerves, directly after their origin, likewise divide into two branches, each of which forms a ganglion; the external nerves after a shorter, and the internal after a longer course. The two external ganglia thus formed send filaments to the terminal portion of the genital organs, while those of the two internal ganglia are distributed to the digestive tube and neighboring organs. 3 With the Araneae, the Galeodea, and Phrynidae, the posterior extremity of the principal ventral ganglion sends off two considerable nervous cords, contiguous, which pass into the abdominal cavity where they are distributed, radiatingly, to the digestive organs, to the pulmonary sacs, to the genital organs, and to other abdominal viscera. Sometimes, before dividing, they unite in a common ganglion. 4

1 This Nervus sympathetic is recurrens was discovered by Brandt, with Epeira; see Mediz. Zool. H. p. 90, Taf. XV. fig. 4, d., and fig. 6, c., or in the Atlas, 1931, p. 110, Taf. VII. fig. 6, b., and Kiemerk. ab. der Mundmagenerven, loc. cit. p. 15, or Ann. d. Sc. Nat. V. p. 94, and XIII. p. 185, Pl. IV. fig. 2, c. This same nerve has been found by Grube (loc. cit. p. 302), with other indigenous Araneae. With Mygale, according to Dugas (Ann. d. Sc. Nat. VI. p. 175), there are, instead of two simple filaments, two lateral ganglionic net-works, from the brain to the stomach.


4 This ganglion has been observed by Trexiranaus (Hau d. Aracb. p. 45, Taf. V. fig. 45), with the indigenous Araneae, and by Dugas (Ann. d. Sc. Nat. VI. p. 175), with Mygale. According to Brandt (Mediz. Zool. II. Taf. XV. fig. 5, and Ann. d. Sc. Nat. XIII. p. 185, Pl. IV. fig. 4), this ganglion is wanting with Epeira, and Trexiranaus (Zeitsch. d. Physiol. IV. p. 95), has vainly sought for it in a Brazilian spider, Blanchard (loc. cit. p. 1384), has found it with Galeodes, and Van der Hoeven (Tijdsch. X. p. 370), with Theleyphonus.

* [§ 302, note 2.] See also Dufour, loc. cit. p. 251. — Ed.

32
CHAPTER IV.

ORGANS OF SENSE.

§ 303.

The multi-articulated antennae with which the Crustacea and Insecta are endowed, are absent with the Arachnidae, or, more properly speaking, they are changed into prehensile and masticatory organs. 1

The palpi, which are absent with only a few Arachnidae, 2 must be regarded as the principal seat of the sense of Touch. These tactile organs always receive two considerable nerves arising from the anterior extremity of the ventral ganglionic mass. 3 A very delicate sense of touch exists, also, in the extremity of the feet, which are well supplied with nerves; and, for this object, the feet of the Opilionina and Phrynidae have the form of multi-articulated antennae.

With the Araneae, this point admits of no doubt, for these organs (the feet) are especially used in the formation of the web.

§ 304.

Although we must grant to the Arachnidae the sense of Taste, and that of Smell; and although many facts show that they have the sense of Hearing highly developed, yet, at present, nothing satisfactory has been discovered either as to the locality or the structure of the organs which are the seat of these senses. 4

§ 305.

The organs of Vision of the Arachnidae consist always of simple eyes (Stemmata); but among the lower Arachnidae, there is a complete series, namely, the parasitic Mites, and allied groups, which are entirely deficient in these organs. 5

The stemmata of the Arachnidae have exactly the same organization as the simple eyes of the Crustacea. They are composed of a simple and convex cornea, of a spherical lens, and of a concavo-convex, vitreous body, which is surrounded by a Retina. Each of these eyes is enveloped, before and behind, by a pigmented tunic corresponding to the Chorioidea; its color

1 See § 306. Latreille (Regne anim. IV. 1829, p. 207), has regarded these mandibles as transformed antennae, but usually they have been considered as the first pair of maxillae. This view of Latreille is the correct one, since the nerves of these organs do not arise from the abdominal ganglia, but directly from the brain, as those of the antennae of Crustacea and Insecta.

2 These palpi are wanting with Psephonogonum, Phoxichilus, Phoxichilidiun and Pallene; see Sarsgny, Mem. loc. cit. I. Pl. V. fig. 3 ; Johnston, Nat. of Euzk, and Det. I. Pl. XVIII. fig. 1-8 ; Milne Edwards, Hist. Nat. d. Crust. Pl. XLI. fig. 6. With the Scorpionsidae, as well as with Obisium, Cheiifer, Phrynus, and Thelyphonus, the palpi are forked, and are used as prehensile organs.

3 See Treviranus, Zeitsch. f. Phys. IV. p. 94, Taf. VI. fig. 4, No. 4 (a Brazilian spider), and Dogger, loc. cit. p. 343, Pl. XVII. fig. 1, n. a. (Milnseum).

4 According to analogy, the sense of taste, with the Arachnidae, is seated probably at the entrance of the esophagus.

5 The eyes are wanting with Demodes, Sarcoctes, Peropterus, Dermanyssus, Theronyssus, Thryosthyphus, Glycyphagus, Ecarus, Argus, Ixodes, &c.
is very variable, and, in front, it terminates between the lens and the vitreous body by a ring which resembles an Iris. When two of these stemmata are contiguous, the pigment tunic is common between them. 2

The number, the situation, the disposition, and the direction of the eyes, present so many variations, that they have been used by zoologists to characterize the genera. Chelifer, Erythroceous, Smaridus, Tetranychus, Arrenurus, and the Tardigrada, have two of these organs on the anterior portion of the back, while with many Orbitaeae, they are lateral and anterior. With Trombidium, there are two eyes also, but they are situated directly above the first pair of legs, on elevate peduncles. 3 With the Pycnogonidae, and with Obisium, there are four eyes situated on the first segment of the body; there are the same number, also, with Bdella, Rhychnopholus, Eylais, Atax, Diplodontus, Hydrachna, and Limnocharis, situated on the anterior part of the back. 4

With the Opilionina, there are two median, larger, and two lateral, smaller eyes. The first of these are situated on a tubercle, and their cornea face right and left. 5 With Galeodes, there are six eyes on the anterior border of the first segment of the body; of these, the middle or largest pair is directed upwards; another, situated in front of these last, forwards; and the remaining pair, inserted above the anterior legs, laterally. 6 The Araneae have, usually, eight eyes; only a few have but six. 7 These eyes, always situated on the cephalothorax, are generally of different sizes with the same individual, and are either grouped symmetrically upon the anterior median line of the cephalothorax, or scattered on its lateral border. 8 The dorsal eyes are directed upwards, and the marginal ones, forwards or laterally.

The disposition and direction of these organs are conformable with the animal's mode of life; some species watch their prey in crevices, fissures, or tubes; while others remain motionless in the centre of their webs, or lurk from side to side,—a kind of life requiring them to look in all directions. The color of the pigment of the eyes is based also upon the same relations; for, with the diurnal species, it is green, reddish, or of a pair, so that each pair would easily be taken for a single eye. With Atax, Diplodontus, and Hydrachna, the two pairs of eyes are widely separated. But with Eylais, and Limnocharis, they are closely approximated. With the young of these aquatic miles, their position is often different (Dungés, Ann. d. Soc. Nat. 1. p. 144, Pl. IX., X.). Wagner's attributing (Lehrb. d. vergleich. Anat. p. 431) compound eyes to certain Hydrachna, is due, without doubt, to his regarding as such the approximated simple eyes. Dujardin (Ann. d. Soc. Nat. III. p. 19), however, affirms that Penthalus has a single eye, composed of eight to ten facets, while some of the species of Orbites and Malgus have only a single stemma situated on the back. 5

2 For the structure of the eyes of Arachnidae, see Saurinier's, De ocul. hom. animali, sect. histol. p. 74, Tab. III.; and Gaede, Nov. Act. Nat. Cur. XI. p. 388 (Myzode); but especially Müller, Zur vergleich. Physiol. d. Gesicht-sm. p. 516, Tab. VII. fig. 8-11, or Ann. d. Sc. Nat. X. 1822, p. 294, Pl. XII. Expl. 1-4 (Androtectus and Galeodes). Brodt (Typhle &c. V., or Ann. d. Sc. Nat. IX. 1823, p. 208) has confirmed Müller's observations for the eyes of Bathus and Myzode; but he observed, also, tubes situated behind the vitreous body, and analogous to those of the eyes of Crustacea and Insecta. Müller, however (Arch. 1836, p. 139), has been unable to find them, but he observed that the fibres of the optic nerve, after having entered the eye, are separated by the long filamented pigment bodies; and he adds, that these fibres should not be confused with the vitreous cones of the foetid eyes, the first becoming opaque in alcohol, while the second preserve their transparency.

2 These pedunculated eyes, already figured by Deguer (loc. cit. p. 57, Tab. VII. fig. 15, y.y.), have been described by Hermann (loc. cit. p. 19, Pl. III. fig. E G.), as Ocelli inferiores; see, also, Trevisiani, Vern. Schrift. I. p. 49, fig. 31, 32, 34, &c. 6

4 With Bdella, the eyes are wholly lateral. With Loc Hydrachna, above named, they are united in pairs, so that each pair would easily be taken for a single eye. With Atax, Diplodontus, and Hydrachna, the two pairs of eyes are widely separated. But with Eylais, and Limnocharis, they are closely approximated. With the young of these aquatic miles, their position is often different (Dungés, Ann. d. Soc. Nat. 1. p. 144, Pl. IX., X.). Wagner's attributing (Lehrb. d. vergleich. Anat. p. 431) compound eyes to certain Hydrachna, is due, without doubt, to his regarding as such the approximated simple eyes. Dujardin (Ann. d. Soc. Nat. III. p. 19), however, affirms that Penthalus has a single eye, composed of eight to ten facets, while some of the species of Orbites and Malgus have only a single stemma situated on the back. 5

4 See Trevisiani, Vern. Schrift. I. p. 24, Tab. 11. fig. 10. The two lateral eyes are wanting with many Opilionidae. According to Tulk (loc. cit. p. 229, Pl. V. fig. 4), there is a pair of muscles inserted on the two middle eyes, by which their contents can be displaced. 6 See Müller, Zur vergleich. Physiol. &c. p. 522, Tab. VII. fig. 11.

5 There are six eyes with Scytodes, Segestria, Dydera, and Oiptotes. 7 See Scutius, Descript. de l'Egypte, loc. cit. Pl. I.-VII. and Halotenaee, loc. cit. Pl. I.-IV., &c.
brownish black, as with the other Arachnoidae; but with the nocturnal spiders, it is replaced by a membrane which has a splendid lustre. With the Phryninae, there are also eight stemmata, of which two are situated on the middle of the cephalothorax, and the remaining six form a triangle composed of three on each of its sides.

With the Scorpionidae, the eyes are the most numerous. There are two large eyes on the middle of the cephalothorax, then a row of from two to five smaller on each side of its anterior border.

The number of optic nerves depends, usually, upon that of the eyes. But the Scorpionidae form an exception in this respect; for their brain sends off, at the side of the two median optic nerves, two other nerves, common, and belonging to the two rows of marginal stemmata, but which do not divide until they have reached these organs. On account of the usually deep position of the brain, the optic nerve is generally of considerable length; but the Pycnogonidae alone differ in this respect from the other Arachnoidae, for, with Phoxichilus, the four eyes are situated directly on the brain, and, with Ammophila, this last sends off, as a common optic nerve to the four eyes, a large, short prolongation.

CHAPTER V.
DIGESTIVE APPARATUS.

§ 306.

The entrance of the digestive canal is surrounded by very variable organs, but, with all, the Mandibles are always wanting. The organs usually called such are only antennae metamorphosed into prehensile and masticatory parts. This is shown not only from the cerebral origin of their nerves, but by the fact that they, or more properly the Chelicere, never act, like the mandibles of the other Arthropoda, in a horizontal direction. Most of the Arachnoidae live on liquid food, and, therefore, the basilar article of the maxillae is more or less abortive, and is rarely used in mastication, while the succeeding articles are changed into a usually very large tactile or prehensile palpus.

In general, the organization of the parts of the mouth with the Arachnoidae may be divided into the following five types:

1. With the Tardigrada, there are real organs for suction. These consist of a kind of sucker, situated on the end of a fleshy proboscis which can be retracted into the head. On each side of this proboscis there are two styles (teeth) which, by means of a special muscular apparatus, can be protruded into the former.

2. With most of the Acarina, the two chelicers are sometimes forniculate or unicomrate, sometimes cultrate or styliform, and by their use, these

10 Trevisanus, Zeitsch. f. Physiol. IV. p. 92; Taf. VI. fig. 3; and Muller, Zur vergleich. Physiol. &c. p. 331; Taf. VII. fig. 10, or Ann. d. Sc. Nat. XVII. p. 258, Pl. XVII. fig. 3.
11 Quatrefages, loc. cit. p. 77, Pl. I. fig. 1v. 2v.
1 See Doyère, loc. cit. p. 319, Pl. XIII.-XV.
§ 306. THE ARACHNOIDAE.

small animals can pierce or cut as may be required. These cheliceres are free, or lodged in a sheath out of which they may be protruded; sometimes they are covered, above or below, by a frontal or chin-like process. In a few instances, these processes are united, forming a proboscis out of which the cheliceres may be protruded.\(^3\) The first pair of maxillae, which are inserted on the sides of the cheliceres, are wholly unfit for masticatory organs, and, being destined for tactile parts, they have the form of palpi. These palpi are sometimes multi-articulated, sometimes uni-articulated, and, from their various modifications, have received the names of *Palpi raptaces, anchorarii, fusiformes, filiformes, antenniformes, valveformes, and adnati.*\(^3\)

3. The Oribatea, which, from their herbivorous nature, hold a distinct place, not only among the Acarina, but also among the Arachnoidae in general, are distinguished also for the organization of their buccal organs. Their cheliceres are retractile, and the first pair of maxillae, situated under them, forms a complete masticatory apparatus, their basilar article being developed at the expense of the rest into a large denticulated piece. The other articles form only a very short palpus.\(^4\)

4. The Pycnogonidae, Opiliones, Pseudoscorpions, Galeopoda, and Scorpionidae, all, have tri-articulated cheliceres. Under these last are situated the first pair of maxillae which have no masticatory character.\(^5\) With the Scorpionidae, and Pseudoscorpions, they are long-forculate, while, with the Galeopoda, the Pycnogonidae and Opilionidae, they are antenniform. With the Phalangidae, only, there is observed on their basilar article, a hairy, obtuse appendage, comparable to a rudimentary maxilla.\(^6\) With the Scorpionidae, the two basilar articles of the pincers are so approximated by their flattened internal surfaces, that they may well be used for the bruising of soft animal substances.\(^7\)

5. With the Phrynidae, and Araneae, the cheliceres have the form of bi-articulated, uniforce antennae. The basilar article of these so-called mandibles is always very thick, and the terminal article consists of a small, very sharp hook.\(^8\) When at rest, this last lies folded on the inter-

\(^{2}\) For the cheliceres of the Acarina, see the descriptions and figures of *Hermann, Duèze, and Dujardin, loc. cit.* These organs are boreculate with the Acarcs, Manyseas and Bolluca; see *Dujardin*, Oeuvres, *loc. cit.*

\(^{3}\) They are unguicate with *Trombidiun, Ergathaeus, Sinarida, Aitar, and Eglus*; see *Freyranus*, Ver. S. S. Mus., *loc. cit.*

\(^{4}\) These are styloform with the *Ie-odea, Tetraphyes, Rhynchospolius, Rhiphig- nathus, and Hyrochaua.* The frontal prolongation is regarded by some authors as an under lip. It is found with *Dermangenus* and *Raphikna- thus*; while, with *Ixodes*, it belongs to the chin, and thus forms an under lip. With *Saradina* and *Sarcopotes*, the cheliceres are encompassed by a kind of tube; see *Dujardin*, *loc. cit.*

\(^{5}\) With *Ixodes*, the cheliceres are ciliate and denticulate on their external borders; see *Savigny*, Descript. de l’Egyp. *loc. cit.*

\(^{6}\) The brevity and inequality of these organs, as noticed by *Audouin* with *Ixodes canadensis*, were due to the circumstance that they were imperfectly and unequally protruded from their sheath.

\(^{7}\) This classification of the palpi belongs to *Du- gès*; see *Ann. d. Sc. Nat.* I. p. 11.

\(^{8}\) I have satisfied myself of the presence of horny denticulated maxillae, fitted for mastication, with *Hoplophora, Celops, Zetes, Oribates, Da- maras*, and with other Oribates.

\(^{9}\) Some Pycnogonidae form the only exception in this respect. With *Phascoloptera*, the cheliceres are simple, bi-articulate and clavate; but with *Endotes*, *Pycnogonum*, and *Phlebichilus*, they are wholly wanting; see *Philippi*, *loc. cit.*

\(^{10}\) With the Phalangidae, only, there is observed on their basilar article, a hairy, obtuse appendage, comparable to a rudimentary maxilla. With the Scorpionidae, the two basilar articles of the pincers are so approximated by their flattened internal surfaces, that they may well be used for the bruising of soft animal substances.

\(^{11}\) It is well known that the Scorpionidae and the other raptaceous Arachnoidae, merely suck their prey; but it is said that *Galeodes* devour completely the insects which it has caught, seizing them with their cheliceres, and eating them piece by piece. During these processes each chelicere acts separately (*Hutton*, Ann. of Nat. Hist. XII. 1846, p. 81, or *Ferrugie's* *loc. cit.*

\(^{12}\) The Phalangidae have probably the same habits, for fragments of insects which they have eaten are found in their digestive canal (*Tulk*, *loc. cit.* p. 243).

\(^{13}\) See *Roessl*, loc. cit. *Taf. XXXVI., and Savigny*, *loc. cit.*
nal side of, or underneath the basilar article. It is erected when the animal, for defence, or for the seizure of its prey, inflicts a poisonous wound; and, for this purpose, the excretery duct of a poison-gland opens at the apex of each of these hooks. The first pair of maxillae is changed, with the Araneae, into very long tactile, and with the Phrynidae, into prehensile organs. Their basilar articles form two upwardly directed prominences, which are contiguous at their bristly, internal borders, and thereby cover the entrance of the oral cavity. As the Araneae bruise, by means of these prominences, their prey which they have seized and taken into their mouth, these parts may be regarded as rudimentary maxillae.

The entrance of the Oral cavity is surrounded, with most Arachnoidae, by a soft, unequal border. This may be regarded, in part, as an upper and under lip, and partly as a tongue. The orifice and cavity of the mouth are often provided with small hairs pointing inwards, among which are sometimes observed horny ridges, which serve, probably, as teeth. The Araneae have this peculiarity, that their large oral cavity has a groove on the median line of the palate, which is continuous into the oesophagus. Its lateral borders may be so approximated that it is changed into a canal. This apparatus is certainly very serviceable to these animals in sucking their prey, after it has been punctured repeatedly, and taken into the mouth.

With very many Arachnoidae, the food, before reaching the proper digestive tube, traverses a very short oesophagus.

With the Araneae, this canal is geniculate, of a horny consistence, and, at the point where it enters the stomach, it presents a prismatic muscular enlargement on which is inserted a large muscle arising from the centre of the dorsal shield and passing through the central opening of the stomach. This serves probably as a sucking apparatus during the prehension and deglutition of food. With the Tardigrada, the oesophagus terminates also by a muscular apparatus of this kind, which, with Macrobiotus, and Emydium, is spheroidal, and, with Milnesium, cylindrical.

§ 307.

The Intestinal canal of the Arachnoidae is formed after two different types.

1. With the Tardigrada, Acarina, Pycnogonidae, Opilionina, Solpugidae, and Araneae, the stomach has a greater or less number of caecal

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9 See Treviranus, Ren d. Arach. Taf. II. fig. 14-16, r., and Brandt, Mediz. Zool. Taf. XV. fig. 9, 13, b.
10 With the Araneae, and Scorpionidae, the entrance of the mouth has a tubal, pilose upper lip. With the Opilionina, there are several such tuberiforms, but with the Pycnogonidae, the oral orifice is prolonged, snout-like, between the maxillae.
13 With the Acarina, Pycnogonidae, and Araneae, Quadrefazes (Compt. rend. XIX. 1844, p. 1182) thinks he has observed a ciliated epithelium in the oesophagus of the Pycnogonidae; but, subsequently, he found that he was deceived, and that vibratile organs were wanting here as with all the Arthropoda.
15 This suctorial apparatus appears to have been well described and understood by Wasmann (loc. cit. p. 19, fig. 13, i. n.): but, already before this, Lyenet (loc. cit. p. 402, Pl. XXI. fig. 4, C. D. E.) had rightly perceived it; while Brandt (Med. Zool. II. p. 87) had taken it for an os hyodae.
16 Dogère, loc. cit. p. 322, Pl. XIII. XV.
diverticuli, of the most varied form and size. It is continuous into a short, small intestine, which passes, in a straight line, to the anus situated usually at the posterior extremity of the body. Before reaching this point, the intestine has, usually, a dilatation bounded by a constriction, which may be regarded as a rectum, or better, perhaps, as a cloaca. With the Tardi-

grada, the stomach is oblong and occupies a large portion of the body. It is divided throughout by numerous constrictions into many irregularly disposed caeca.1

With the Acrinida, whose anus is placed nearer the middle of the belly, there are, nearly always, three short caeca at the anterior part of the stomach, and two, longer and more or less constricted, in the lateral regions of the abdomen. With some species of parasitic Mites, these appendages of the stomach are bifurcated.2 With the Pycnogonidae, the stomach is short, but has five pairs of very long caeca, some of which penetrate into the two cheliceres, and others into the eight long legs, even to the extremity of the tibiae.3 With Galcades, also, these appendages penetrate the legs, and the base of the cheliceres and palpi.4 With the Phalangidae, the stomach is spacious and has thirty appendages of varied size. Thus, at its upper part, there are four rows of short caeca, and, upon the sides, three pairs, very long and extending over nearly the whole length of the visceral cavity; the middle pair of these last has, moreover, short sacculi.5 With the Araneae, the stomach is situated in the cephalothorax, and presents a very remarkable disposition. At the posterior extremity of the thoracic cavity, and directly behind the sucking apparatus, it is divided into lateral halves which extend areately in front, and, uniting, form a ring from which are given off laterally five pairs of caeca extending towards the points of insertion of the legs and palpi.

The intestine arises from this annular stomach, opposite the sucking apparatus. It traverses the abdomen on the median line, and terminates, before reaching the anus, in a cloacal dilatation.6

2. With the Phrynidæ,7 and Scorpionidae,8 the intestinal canal is very simple compared with that just described. It consists of a straight

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1 Dugès, ibid. p. 324, Pl. XV.
2 See Lymer loc. cit. Pl. XIII. fig. 11, 12; Dugès, loc. cit. 1. Pl. I. fig. 27. Pl. VII. (Eury-

thraeus, Dermanyssus and Ixodes); also, Tre-

viraus, Zeitsch. f. Physiol. IV. p. 189, Taf. XVI. Ixodes has dichotomous stomachic appendages, of

which the posterior, at the extremity of the body, curve first downwards, then forwards with a long

course. These various caeca of the Acrina often

appear, especially when filled with food, clearly de-

fined, through the skin. But when empty, they

are frequently overlooked in the small species, from the tenuity of their walls. However, I have

always succeeded, even with the smallest Ornibates, in distinguishing the walls of the intestine, especially when it contained food. I must, therefore, consider as wholly erroneous, the opinion recently advanced by DuJardin (Ann. d. Sc. Nat. III. p. 14, or Compt. rend. loc. cit. p. 1130), that the food eaten by the Acrina does not pass through a distinct digestive tube, but is freely diffused in the interstices of the visceræ.


531, and Quatrefages, loc. cit. p. 72, Pl. I. 11.

4 Blanchard, loc. cit. p. 1384.


6 For the annular stomach of the Araneae, and

on which, with Tzenaria, Trevisanus (Bau d.

Arach. p. 30, Taf. II. fig. 24, v. b.) has found only

four caeca, see Brandt, Mediz. Zoö. II. p. 89, Taf.

XV. fig. 6, or Ann. d. Sc. Nat. XIII. p. 152, Pl.

IV. fig. 2, or Isis, 1853, p. 1145, Taf. VII. fig. 6;

also Owen, Lectures, &c., p. 257, fig. 110; and Was-

mann, loc. cit. p. 11, fig. 17, 18. According to

this last observer, the four pairs of stomachic caeca,

with Mygale, bend downwards to the base of the

eight legs, in order to pass into the thorax where

they ramify and interanastomose.

With Argyroneta, and some species of Epeira, according to Grube (Müller's Arch. 1842, p. 205), the lateral halves of the stomach are not united in a ring at their anterior extremity, but are only con-

iguous.

With the Araneae, the walls of the stomach con-

tain finely-granular cells which, by reflected light, have a milky aspect, and secrete perhaps a kind of

gastric juice.

7 Van der Hoeven, Tijdschr. &c. IX. p. 68

(Phrynas).

8 Meckel, Beiträge, loc. cit. p. 107, Taf. VII.

fig. 13; Trevisanus, Bau d. Arach. p. 6, Taf. I.

fig. 6, and Müller, loc. cit. p. 44, Taf. XI. fig.

22.
tube, of nearly equal size throughout, without a stomachic dilatation and without caeca, which opens by an anus at the posterior extremity of the body.\(^9\)

\section*{§ 308.}

The Salivary glands exist with, perhaps, all the Arachnoidae; for, they are found even in many of the lower forms, where their presence would be least expected. With the Tardigrada, there are on each side of the sucking apparatus, large, lobulated glandular tubes, which appear to be organs of this nature, although their outlets have not yet been distinctly traced.\(^6\) With the Oribatae, there is at the anterior extremity of the body, a pair of similar tubes, but simple and colorless, which extend to the mouth, and have undoubtedly a salivary function.\(^5\)

With \textit{Ic nodes}, these organs are extraordinarily developed, consisting of two large masses of vesicles situated on the sides of the anterior part of the body, and opening by short ducts into two multiramose excretory canals. These last, whose walls are traversed by a solid spiral filament, open into the buccal cavity at the base of the lip-like process.\(^3\)

With the Araneae, a slit in the upper lip leads into a cavity situated above the palate, and at the base of this cavity is a transparent, glandular mass, which, very probably, secretes the saliva; this flows up through the slit in question, and moistens the substances from which the animal extracts its food.\(^4\) As salivary organs should also be considered the two pairs of glandular tubes, which, with the Scorpionidae, are situated on the sides of the anterior part of the body, and extend forwards to open into the oesophagus.\(^5\)

With the Araneae, and Scorpionidae, there is a Liver distinct from the digestive tube, which, for a long time was regarded as an adipose mass. With the Tardigrada, Acarina, Pycnogonidae, and Opilionina, the walls of the stomachic appendages are of this nature, for they are glandular and composed of granular and usually yellowish-brown cells.\(^6\) With the Araneae, the brown or dirty-yellow liver is very voluminous, filling a large portion of the abdominal cavity, and enveloping most of the other viscera.

At first sight, it appears to be a compact mass, but, further examined, it is found composed of numerous multiramose, closely-aggregated caeca. The walls of these are thick, and crowded with hepatic cells, and they open into the digestive canal near its middle by four short hepatic ducts.\(^5\)

\begin{itemize}
  \item \(^9\) With the Scorpionidae, the anus is situated on the penultimate caudal segment.
  \item \(^1\) See \textit{Duguay}, loc. cit. p. 521, Pl. XIII.-XV.
  \item \(^2\) I have seen these glandular tubes with \textit{Hoplomphora}, \textit{Zetes}, and \textit{Oribates}.
  \item \(^3\) The salivary glands of \textit{Ixodes ricinus} resemble exactly the botryoidal ones of many of the Insects.
  \item The secretory vesicles of the saliva are filled with transparent nucleated cells and surrounded by numerous ramified tracheae with which it is impossible to confound the excretory ducts of these glands; for with these last the spiral turns of thin filament are very wide apart, while, in the tracheae, the spiral windings are very close together.
  \item This glandular apparatus has been seen by \textit{Was mann} (loc. cit. p. 8, fig. 16) with \textit{Mygale}; I have found it also with other Araneae.
  \item \(^5\) See \textit{Müller}, loc. cit. p. 52, and \textit{Newport}, Philosoph. Trans. 1843, Pl. XV. fig. 39.
  \item \(^6\) With the Tardigrada, Acarina, and Opilionina, at least, I have seen, distinctly, hepatic cells in the walls of the stomachic appendages. See also \textit{Duguay}, loc. cit. p. 527, Pl. XV.
  \item \(^7\) \textit{Treviranus} (Ran. d. Arachn. p. 29, 47, Taf. XI. fig. 24, dd., and Taf. V. fig. 47) had already observed the communication between the liver and the digestive organs. The remaining points in the structure of this organ have been rightly estimated by \textit{Dugas} (Ann. d. Sc. Nat. LV. p. 179), \textit{Grube} (loc. cit. p. 259), and \textit{Was mann} (loc. cit. p. 18, fig. 17, n., n., 20-22). See also Owen, Lectures, Ec., p. 258, fig. 110, l. i.
\end{itemize}
§ 309. THE ARACHNOIDAE. 381

With the Scorpionidae, the liver is also very large, and composed of many lobes. It occupies the two sides of the abdominal cavity even to the base of the tail, and closely encompasses the intestine, the heart, and the genital organs. The ramifications of the biliary canals traverse, in groups, the parenchyma of this liver, and the bile is poured into the intestine by five pairs of short, excretory ducts, equally, but very widely separated from each other. 8

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CHAPTER VI.

CIRCULATORY SYSTEM.

§ 309.

With many Arachnidae, the circulatory system consists only of a Heart or an articulated dorsal vessel. With the higher forms, there is, in addition, a system of more or less developed blood-vessels; while with the lower species, such as the Tardigrada, the Acarina and the Pycnogonidae, not only all these vessels, but the heart, also, is absent. There is, therefore, in these last, no regular circulation, but the nutritive fluid fills all the interstices of the body, and, by the aid of the muscular movements and the contractions of the intestinal canal, is transferred in an irregular manner hither and thither in the visceral cavity and in the extremities. 9

The Blood of the Arachnidae is entirely colorless, and has a slightly milky aspect only when in considerable quantities. It contains a few granular blood-cells of a pretty regular, spheroidal form, and some very small, isolated granules, derived perhaps from broken blood-cells. 10

8 See Meckel, Beitr. &c. p. 107, Taf. VII. fig. 13, 15; this author has seen four pairs of hepatic ducts. See, also, Trexmanus, fass d. Arachn., p. 8, Taf. I. fig. 6. A. v., and Muller, loc. cit. p. 35, 46, Taf. II. fig. 22, D. D.; finally Newport, Philosoph. Trans. 1843, Pl. XIV. fig. 32.

9 C. A. S. Schultze (in his memoir "Macrobiotus Hufelandii") thinks he has observed blood-vessels in the Tardigrada; but neither Doyère (loc. cit. p. 310) nor I have been able to find them. For the intersticial circulation of the Pycnogonidae, see Quatrefages, loc. cit. p. 76. Van Beneden has observed, in the extremities of these animals, regular blood-currents produced apparently by contractile membranes at the base of the legs; see Institut. No. 627, or Froriep's neue Notiz. XXXVII. p. 72.

10 For the blood of the Arachnidae, see Wagner, Zur vergleich. Physiol. d. Blutes, Heft. I. p. 27, fig. 11 (Scorpio europaeus); Horn, Das Leben des Blutes, p. 10, Taf. I. fig. 13 (Tegenaria domestica), and Doyère, loc. cit. p. 300, Pl. XV. fig. 5 (Tardigrada).
§ 310.

With the Arachnoidae, the circulatory organs, when present, are disposed in the following manner:

With the Phalangidae, they consist only of a Dorsal Vessel, which is three-chambered, and attenuated at both extremities. 1

With the Araneae, the dorsal vessel is fusiform, and has many constrictions. It is situated principally in the abdomen, being attached to its dorsal wall by triangular transverse muscles. This heart, which extends also into the cephalothorax, sends off from each extremity and from its sides, many ramified, vascular canals, which are certainly Arteries.

The two of these last arising directly behind the peduncle of the abdomen, are distributed to the pulmonary sacs, while those following penetrate chiefly the liver. All these vessels gradually disappear in the parenchyma of the body, and the blood, after its effusion, continues to circulate in the lacunae, and, without the intervention of veins, is returned to the heart, or more properly into the blood-reservoir which corresponds to the dorsal sinus of the Crustacea. Thence it enters the heart through its lateral, valvular openings. 2

The vascular system is most highly developed with the Scorpionidae. For, here, not only is there an articulated Heart and Arteries, but also a Venous system. 3 The cylindrical heart whose walls contain transverse and longitudinal muscular fibres, is retained in place between the diaphragm of the cephalothorax and the last abdominal segment, by several transverse triangular muscles. It has eight chambers whose size diminishes from before backwards. At each extremity it is prolonged into an

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1 See Tulli, loc. cit. p. 240, Pl. IV. fig. 17, H., and Treviranus, Vern. Schriff. I. p. 31, Taf. III. fig. 16, k., and fig. 18.*

2 For the vascular system of the Araneae, see Meckel, in his translation of Cuvier's Locoss et Arach. p. 28, Taf. XI. fig. 28-31, also his Vern. Schriff. I. p. 35, Taf. I. fig. 1; Goede, Nov. Act. Nat. Cur. XI. p. 355, Tab. Xl. fig. 3 (Mugate), and Brandt, Bidol. Zool. H. p. 79, Taf. XV. fig. 16, 17. See also Duques (loc. cit. p. 181), who has been unable to find the venous system with the Araneae, but, at the same time, traced the heart even into the cephalothorax. Wenzenn (loc. cit. p. 16, fig. 21), on the other hand, affirms that he has observed, with Mugate, venous trunks which entered the heart above the points of origin of the arteries. The analogy between the heart of Crustacea and of Araneae has been especially pointed out by Straus (Consid. &c. p. 335, and Traité d'Amat. comp. II. p. 241), and since confirmed by Grant (Outlines, &c. p. 452) and Grube (loc. cit. p. 509).*

3 Treviranus (Bau d. Arach. p. 9, Taf. I. fig. 7), and Muller (loc. cit. p. 35, Taf. II. fig. 22), were acquainted with only the heart and larger vascular trunks of the Scorpionidae; but Newport has given of the blood system of these Arachnoidae a complete and masterly description accompanied with very beautiful figures; see Phyllo. Trans. 1844, p. 286, Pl. XIV. XV., or Porteg's neue Notiz. XXXIX. p. 51, fig. 38-40.

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* [§ 310, note 1.] Blanchard (loc. cit. Ann. d. Sc. Nat. XII. 1843, p. 333) has extended our knowledge of the circulatory system of this family. The dorsal vessel terminates behind in a small vessel which runs to the extremity of the body. In front it passes into an artery of considerable size, which passes under the brain and sends off small branches to the mesogaster. At the base of this artery the ophthalmic artery is given off, which bifurcates behind the eyes. From this portion of the heart also pass off branches to the stomach. This naturalist declares the existence here of his peritracheal system, which, together with the heart, he says he has injected through the lacunae. — Ed.

1 [§ 310, note 2.] According to Blanchard (loc. cit.), the blood, in the Araneae, passes to the respiratory organs, which it penetrates by a kind of infiltration ; from the lacunae of the walls of the lungs it is taken to the heart by means of the pulmonary-cardiac vessels which have hitherto been taken for arteries. There are six pairs with Epeira diadema. But with those Araneae which have both lungs and tracheae, such as Segestria, Dysdera, &c., there is some modification, although the arterial system resembles that of the Araneae essentially pulmonary; the heart is smaller and has fewer chambers, and the true arteries seem to lose their importance and give place to the peritracheal system of circulation. — Ed.
arterial trunk. The anterior of these arteries very soon ramifies, and distributes blood to the feet, the pincers, the cheliceres, and to all the organs in the cephalic extremity. Two of its branches, bending downwards, embrace the oesophagus, and then join in a large common vessel called the Supravisceral artery, which lies upon the ventral cord and accompanies it to the caudal extremity, giving off, in its course, numerous lateral branches.\textsuperscript{4} The posterior arterial trunk is distributed in like manner to the posterior extremity, and gives off, right and left, numerous branches. The middle chambers of the heart send off, each, laterally, shorter arteries, which are distributed to the neighboring organs. Beside these arteries of the muscles and viscera, these animals have, also, a special Visceral artery, arising from the anterior arterial trunk before it divides into the two branches which form the supra-spinal artery. The visceral artery runs backwards towards the digestive tube, and sends branches to the liver.\textsuperscript{5} The terminal ramifications of these various arteries are directly continuous, it is said, with a venous system.\textsuperscript{6} In this last may be noticed, especially, a Sub-spinal vein, by which the blood is carried to the pulmonary sacs; thence to be borne to the heart by special vessels. These last open, probably, into a sinus, from which the blood passes into the heart through lateral openings, two of which exist in each of its chambers.\textsuperscript{f}

\textsuperscript{4} This supra-spinous artery had been seen, it would appear, by \textit{Müller} (loc. cit. p. 62, Taf. I. fig. 5. r. r.), but he took it for a ligament.

\textsuperscript{5} According to \textit{Newport}, this visceral artery, which is simple with \textit{Androctonus}, is divided into two trunks with \textit{Buthus}.

\textsuperscript{6} \textit{Newport} speaks in his memoir of various anastomoses occurring between the arteries and veins with \textit{Scorpio}. But, as he nowhere describes precisely this point, and has not distinctly indicated it in his plates otherwise so beautiful, I demur admitting that, with the Scorpidæ, the arteries pass directly into the veins, and therefore, that these animals have a system of capillary vessels. This direct communication between these two systems does not exist with the other Arachnoidæ, neither with all the other Arthropoda in general.\textsuperscript{f}

\textsuperscript{f} [§ 310, note 6.] In regard to the question of capillaries with the Scoptidæ, a remark of \textit{Blanchard} (loc. cit.) may be given. He says, "I have proved with an entire certainty that the blood is distributed in all the cavities of the body, as with all the Arachnida, and that it is conveyed to the lungs simply by means of the heart. Most of the vessels which arise from the sides of several of the chambers of the heart have appeared to me to be pulmonary-cardiac vessels, wholly analogous to those we have described with the Araneæ." — \textit{Eb.}

\textsuperscript{f} [§ 310, end.] For further details on the circulatory system of the Arachnoidæ, see the memoir quoted above of \textit{Blanchard}. This naturalist has sought to extend his doctrine of the peritracheal circulation, to the different sections of the Arachnoidæ. — \textit{Eb.}
Respiratory System.

§ 311.

The higher Arachnoidae respire by tracheae, or by lungs; but in the lower, namely, the Tardigrada,^1^ the Pyenogonidae,^2^ and some parasitic Acarina,^3^ no traces of respiratory organs have yet been found. With these animals therefore the respiration must be cutaneous.

Many Acarina, the Opilionina, the Pseudoscorpii and the Solpugidae, breathe by tracheae, while the Araneae, the Phrynidae and the Scorpio-nidae breathe by lungs. On this account, these animals have been divided, in zoological systems, into the Arachnidae tracheariae and pulmonariae. But this classification is valueless, since it has been shown that the Araneae possess both lungs and tracheae.

§ 312.

With the Acarina, the Tracheae are exceedingly tenuous, and it is only in the larger species that the spiral filament of these organs can be observed. They arise usually by a simple tuft from two stigmata which are sometimes concealed between the anterior feet, as with the Hydrachnea, the Oribatea, and the Trombidina, sometimes very apparent above the third pair of legs, as with the Gamasacca, and sometimes behind the last pair of legs, as with the Ixodea.\(^4\)

With the Hydrachnea, which live in the water and never come to the surface to take in air, the tracheae possess, probably, the power to extract from the water the air necessary for respiration.\(^5\)

With the Pseudoscorpii, there is, on the ventral surface of the two first abdominal segments, a pair of lateral stigmata, with four short but large tracheal trunks from which arise numerous unbranched tracheae spreading through the entire body.\(^6\) With the Solpugidae, whose tracheae

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1 See Dujardin, loc. cit. p. 346.
2 See Quatrefages, loc. cit. p. 78.
3 Demodelx, Sacopotes, Acarus, &c.
4 With Trombidium, there arise two simple and very distinct tracheal tufts from the two stigmata situated behind the second pair of legs (Treviranus, Verne, Sclitif. I. p. 47, Taf. VI. fig. 32, t. l.). These tracheae do not proceed directly from the stigmata, but from two large, short trunks unobserved by Treviranus.
5 With Gamasacca, and Uropoda, there are given off, from the two ramified tracheal tufts, two unbranched tracheae which, remaining of the same size, describe a slightly arcuate course along the lateral borders of the ephalothorax and terminate in cæca at the base of the parts of the month. The two lateral stigmata of Ixodes have been described by Lyenet (loc. cit. p. 288, Pl. XIV. fig. 3, 5), Treviranus (Geochel. 1. Physiol. IV. p. 157, Taf. XV. fig. 2, 4, 5), and Audouin (Ann. d. Sci. Nat. XXV. p. 419, Pl. XIV. fig. 2, q. r. s.). For the trachea of the Acarina, see, moreover, Dujardin (Ann. d. Sci. Nat. III. p. 16, or Compl. rend. loc. cit. p. 1169). It will be difficult, I think, to prove the assertion of Dujardin, that, with these animals, the trachean system serves exclusively for the act of expiration, inspiration being performed wholly by the skin.
6 Dujardin (Traité d. Physiol. II. p. 549) is certainly right in placing the trachea of the Hydrachnea in the category of Branchiata trachaea, which are so widely spread with the aqueous larvae of Insecta (see below).
7 According to Audouin (Ann. d. Sci. Nat. XXVII. 1852, p. 62), the trachea of Oribiscus are ramified, a statement which I have been unable to verify. It has already been stated that the scar-like fossae on the abdomen of Cheiifer have been erroneously taken for stigmata (§ 258, note 4). The trachea of the Pseudoscorpion are so easily seen by the microscope that it is incomprehensible how anatomists should have remained so long
ramify through the whole body like those of insects, there are three pairs of stigmata.\(^6\) With the Dhalangidae, the trachean system is highly developed, arising from two stigmata concealed under the coxae of the posterior legs, each of which has a horny valve. The two large trunks given off from these stigmata, run obliquely to the cephalic extremity; they intercommunicate by a transverse anastomosis, and give off, in all directions, numerous branches which are spread over the abdominal viscera, and penetrate even the palpi and legs.\(^6\)

With many of the Araneae, there are, on the under surface of the abdomen, two orifices which lead into two pulmonary sacs, beside two other openings belonging to the trachean system. With Segestria, Dysdera,\(^6\) and Argyroneta,\(^7\) there arise from these two stigmata two large trunks surrounded by a kind of horny trellis-work. From the extremity of these trunks are given off innumerable, very small tracheae, which are unbranched and without the spiral filament. They are disposed in tufts, and are distributed, some in the abdomen, and others in the cephalothorax, penetrating even to the extremity of its members. With Salticus, and Micryphantes,\(^8\) the two stigmata are situated at the posterior extremity of the body, far removed from the pulmonary sacs, and send off, directly, two tufts of unbranched tracheae, which are distributed exclusively to the abdominal viscera.\(^9\) There is, with the other Araneae, a trachean system, very imperfect it is true, which has hitherto been overlooked by anatomists. Directly in front of the spinnerets, there is, with most species, a transverse fissure difficult to be seen, which leads into a very short trachean trunk. From this trunk are given off four simple tracheae which, singularly, are not cylindrical, but are flattened, riband-like, and without a trace of a spiral filament; these extend, with a gradual attenuation, to the base of the abdomen. These riband-like, silyver tracheae are composed of a thin, but solid, homogeneous membrane, which is enveloped by a soft, transparent pellicle corresponding to a peritoneum. The air received into these organs is separated into as fine portions as that of the lungs. These tracheae differ therefore, prominently, from those of the other Arachnidae.\(^{10}\)

\(^{1}\) See Müller, Isis, 1829, p. 711; and Milne Edwards, Regne Anim. Insect. Arachnides, PI. II.
\(^{2}\) Trouessart, Verh. Univ. 1832, p. 32, Taf. IV. fig. 19, and Tulk, loc. cit. p. 527, Pl. V. fig. 33.
\(^{4}\) Grube, loc. cit. p. 300, and Menge, loc. cit. p. 22, Taf. I. fig. 6-14.
\(^{5}\) Menge, loc. cit. p. 23, Taf. I. fig. 15.
\(^{6}\) I have had an opportunity to satisfy myself of the existence of this interesting trachean system with Segestria, Argyroneta, Salticus, and Micryphantes. I should also add that the principal trunks are flattened, and that the contained air is finely divided, while that in the cylindrical tracheae given off from these trunks, forms a continuous column.
\(^{7}\) I have found this trachean system with Epeira, Tetragnathus, Drassus, Clubions, Theridion, Lyosa, Diomede and several others. I have been unable to perceive it in individuals escaping from the egg. Thomius velatus is the only species in which the four flattened tracheal trunks are ramified, and thus serves as the passage to the most highly developed trachean system of Salticus. By direct light, they appear black, and thus it is possible that they may have sometimes been taken for urinary canals. But this error is unnecessary, for these last vessels burst from the slightest pressure and diffuse granular contents, while the tracheae under such treatment become transparent, their contained air making its escape, and when the pressure is withdrawn they resume their black color.\(^{*}\)

\(^{10}\) § 312. note 16. See also for these anomalous tracheae, Blanchard (loc. cit. Ann. d. Sc. Nat. XII. 1848, p. 545), who regards them as only elongated pulmonary sacs; but especially Leuc.-

\(^{11}\) bart (Über den Bau und die Bedeutung der sog. Langen bei den Arachniden, in Siebold u. Klü-
§ 313.

The Lungs of the Arachnoidae consist of round sacs situated near the lower surface of the abdomen and communicating, externally, by transverse fissures. Their internal surface has numerous thin solid lamellae, triangular or rhomboidal, and connected together like the leaves of a book. By reflected light these lamellae have the same silvery lustre as the tracheae, although, seen by direct light, they appear of a deep-violet, nearly black color. Each of these is formed by a membranous fold, between the two leaves of which the air enters from the general cavity of the lung and is divided into very minute portions. No traces of blood-vessels have been found in these Pulmonary lamellae. It is therefore very probable that the blood of the pulmonary arteries is diffused into the parts surrounding the lungs, and in this way bathes the lamellae.\(^1\)

With the Scorpionidae, the four anterior segments have, each, on their under surface, a pair of stipitana. These animals have eight pulmonary sacs, in each of which there are twenty fan-shaped lamellae.\(^2\) The genus *Phrynus* has only two pairs of pulmonary sacs, the stipitana of which are placed between the first and second, and the second and third abdominal segments. But each sac has eighty lamellae.\(^3\) With the Araneae, there are only two lungs occupying the base of the abdomen. The number of their lamellae is considerably less than in the preceding groups. But with the Mygalidae only, there is a second pair of lungs directly behind the first. The place occupied by these organs, is indicated, with the Araneae, by a triangular horny plate, at the posterior border of which is a stigma.\(^4\)

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1. These organs, with which no motions have been discovered, have been called Branchiae by many Zootomists. But the name of Lungs is very appropriate since the respiration is aerial and not aquatic.

2. For the lungs of the Scorpionidae, see Meckel, Transatl. of Leçons d. Anat. comp. of Cutier, Th. IV., p. 291; *Treveranus*, Bau d. Arach. p. 7, Taf. 1., and Beobacht. aus d. Physiol. p. 25, fig. 40-42; Müller, Isis, 1828, p. 709, Taf. X. fig. 1-3, and in Meckel's Arch. loc. cit. p. 39, Taf. II. fig. 11-13. Muller has very correctly, and in the above-mentioned manner, understood this respiratory apparatus, while, on the other hand, *Treveranus* and other anatomists, think that the air, instead of entering through the leaves of the pulmonary lamellae, passes over their external surface, and that the blood penetrates between the two plates composing the leaves. *Newport* (Philos. Trans. ker's Zeitsch. 1849, I. p. 240) who, contrary to Blanchard, advances the view that these organs are only a form of tracheae, infra-formed, and which are without the spiral filament, because their simple, unbranched condition does not require, like the ramose tracheae, a spring-like structure, to prevent them from collapsing. This view put forth together with the general doctrine that the pulmonary sacs of the Arachnoidae are, likewise, but modifications of the tracheal type, has many facts deserving the attention of anatomists, and especially the developmental relations of the spiral thread as observed in the embryos of these animals. — En.

3. See *Van der Hoeven*, Tijdsch. loc. cit.

4. The lungs of the Araneae have been studied by Meckel (Transatl. Leçons d'Anat. comp. of Cutier, loc. cit. p. 290), *Treveranus* (Bau d. Arach. p. 24, Taf. II. and Beobacht. Beobacht. loc. cit. p. 29, fig. 43-47), *Gaede*, Nov. Act. Nat. Cur. XI. p. 335, *Mysale*; but especially by *Muller* (Isis, 1828, p. 709, Taf. X. fig. 4-6). See also *Menge*, loc. cit. p. 21, Taf. I. fig. 6-9. I am unable to say by what means the blood returns to the heart, whether by a direct course, or, more or less circumstantially through the interstices of the parenchyma, for there are no veins.
CHAPTER VIII.

ORGANS OF SECRETION.

I. Urinary Organs.

§ 314.

With most Arachnoidae, there are small, usually multiramose, glandular tubes, which open into the cloaca. By their structure and the nature of the fluid they secrete, they exactly resemble the Malpighian vessels of the Insecta, and like them, also, they have, for a long time, been regarded as hepatic organs; but now, they are known to be positively those of an urinary nature. The urine is usually accumulated in the cloaca, and consists of a troubled, dirty-white liquid, rarely reddish; and, by direct light, is found to hold in suspension innumerable dark molecules.

These organs appear to be absent with the Tardigrada, and Pycnogonida. But, on the other hand, they are easily observed with many Aracina, where they consist of simple or ramose white tubes, situated between the appendages of the stomach. With the Phalangiidae, there are two pairs of urinary canals which wind between the stomachie caeca. With the Araneae, these organs are numerous, multiramose, and of a white or reddish color. Their very small branches penetrate between the different portions of the liver, and end in two principal trunks or ureters, which open into a cloaca provided with a kind of diverticulum. With the Scorpionidae, the organization in this respect is quite similar, and the canals, ramified in various ways, enter, some the interstices of the hepatic lobes, while others surround the digestive canal. They pour their product into the cloaca by two ureters which are situated back of the biliary canals.

1 I have discovered without trouble, these canals with the Hydrachnea, Gamasca, Trombidina, and Ixodes. *Treviramus* (Zeitsch. f. Physiol. IV. p. 189, Taf. XVI. fig. 8, n. n.) had already observed their insertion into the cloaca with *Ixodes*. With *Ixodes ricinus*, where they are simple and flexuous, I have seen them ascend even to the anterior extremity of the cephalothorax; this is entirely so with *Ixodes americanus*. The canals, which with *Nixea*, *Treviramus* (loc. cit. fig. 7, p. p.) has regarded as salivary organs, are certainly only the anterior extremities of the urinary canals. The two species of *Ixodes* just mentioned have their cloaca filled with a white urine.

2 See *Treviramus*, Verm. Schrif. I. p. 31, Taf. III. fig. 16, 17. *Tulk* (loc. cit. p. 249, Pl. IV. fig. 17) who has been unable to trace these canals to their points of insertion on the intestine, has taken a portion of them for salivary organs.

3 Ramdohr (loc. cit. p. 206, Taf. XXX. fig. 2), and *Treviramus* (Bau d. Arach. p. 36, Taf. II. fig. 24) were only imperfectly acquainted with the urinary canals of the Araneae. They have been more exactly described by Brandt (Media, Zool. II. p. 89, Taf. XV. fig. 6, 17, or Ann. d. Sc. Nat. XIII. p. 183, Pl. IV. fig. 2, 3); but see, especially, Wagman, loc. cit. p. 17, fig. 11, 21-28 (*Mygale*). In most species, the urine is of a dirty-white color; but with *Mygale*, it is reddish. In several individuals of a large species of *Mygale* preserved in alcohol, I have found, in the ureters, hard, reddish concretions which *Dugas* (Ann. d. Sc. Nat. VI. p. 190) had already observed. Treated with nitric acid and ammonia, I obtained purpuric acid.

4 See *Treviramus*, Bau d. Arach. p. 36, Taf. I. fig. 6, and *Müller*, loc. cit. p. 47, Taf. II. fig. 22. This last anatomist says that these glandular canals communicate with the heart, but he has probably confounded them with the blood-vessels.
II. Organs of Special Secretions.

§ 315.

Very many Arachnidae have Poison-glands, the product of which is excreted through the extremity of a hollow claw. With the Phrynidae, the Araneae, and some Acarina, there are two such glands in communication with the terminal hooks of the cheliceres. They have been often taken for salivary organs. With the Trombidina, there are, on each side of the cephalothorax, two small, flexuous, colorless, glandular tubes, which, at their anterior extremity, are dilated, each, into a cylindrical, thin-walled poison-reservoir. From this reservoir arises a long, narrow canal, which runs to the cheliceres. 1 With the Araneae, the poison-apparatus consists of two tubes, often a little curved, and surrounded by a layer of flattened, spiral, muscular fasciculi. 2 These two glands are situated at the base of the cheliceres, extend more or less into the cephalothorax, 3 and, in front, become suddenly attenuated, forming a narrow excretory duct which terminates at the apex of the hollow claw of the cheliceres. 4 With the Scorpionidae, this apparatus is situated in the last caudal segment; it consists of two oval vesicles, whose excretory ducts open at the apex of the sting situated on the end of the tail. These two glands are surrounded by a layer of flat, circular, smooth, muscular fasciculi. 5

With the Aranea, there is another and very remarkable secretory apparatus, — the Silk organs. Its product is a viscous, transparent liquid which hardens quickly on exposure to the air, forming threads. It escapes by three, rarely by two pairs of spinnerets, situated behind the anus. 6 The glands which secrete it are composed of transparent nucleolated cells, and are of very variable form and disposition, but always situated in the midst of the abdominal viscera. About five kinds of these glands may be distinguished, although not always simultaneously in the same individual. The threads have probably different qualities, according to the glands from which they are secreted.

The genus Epeira, containing all these five kinds of glands, will serve as the type for their description. There are observed: 7 1. Small pyriform follicles, aggregated in groups of hundreds, and having short excretory

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1. The two poison-glands of the Trombidium holosceles, and Raynochelopus phalanoides, have the form of a ring with a small opening. Trechiramus (Verm. Schrift. I. p. 48, Taf. VI. fig. 34) has described only very imperfectly these glands with the first mentioned of these animals; and not having seen their excretory ducts, he took them for salivary glands. Duzès (Ann. d. Sc. Nat. III. p. 10), on the contrary, perceived their true relation to the cheliceres.

2. It is remarkable that these muscular fasciculi present such different histological characters. I have seen them distinctly stained with Lyconia, Drassus, Tegenaria, and Micrphanes. They are smooth with Epeira, Thomisus, Cuphona, and Cygale; with Solitica, they present obscure transverse lines, so that I am undecided whether they belong to the first or to the second of these categories.

3. With Cygale, these glands are entirely concealed in the basal article of the cheliceres.

4. Trechiramus, Rau d. Arachn. p. 51, Taf. II. fig. 21, 22; Lyconia, loc. cit. p. 297, Pl. XX. fig. 16, 17; Brandt, Mediz. Zool. II. Taf. XV. fig. 6, or Ann. d. Sc. Nat. XIII. Pl. IV. fig. 2; and Wasmann, loc. cit. p. 19, fig. 25, 26. For the intimate structure of these glands, see Meckel, in Muller's Arch. 1849, p. 83. Muller, in Meckel's Arch. loc. cit. p. 52, Taf. I. fig. 7, 8. Serres (loc. cit. p. 90) regards the portion of these glands which is surrounded by muscular fibres, as a reservoir of poison, and that this last is secreted by immeasurable glandular follicles enveloping the muscular layer. In fact, with Scorpio eurypus, I have seen this layer covered, externally, with a stratum of cylindrical cells.

5. The Mygalineae have two pairs of these papillae, or spinnerets, instead of six, the usual number.

canals, which are interlaced in a screw-like manner, and open at the six spinnerets;\(^8\) 2. Six long, flexible tubes, which gradually enlarge into as many pouches, and are then continuous, each, into an equally long excretory duct which forms a double loop; 3. Three pairs of glandular tubes similar to the preceding, but which open externally through short excretory ducts; 4. Two groups of multiramose follicles, whose pretty long excretory ducts run to the two upper spinnerets; 5. Two slightly ramified caeca, varicose at intervals, and which terminate, by two short excretory ducts, in the middle spinnerets.

Most Araneae have three pairs of spinnerets, that is, papillae in the form of an obtuse cone; the middle pair of these is composed of two, and the anterior and posterior pairs, of three articles. The apex of these papillae defines the passage of the thread, and is surrounded by stiff bristles and hairs, and dotted with numerous small, horny tubes, which are only prolongations of the excretory ducts. Each of these tubes is composed of two pieces; one, basilar and thick, the other, terminal and very small, and through the orifice of which the web-liquid escapes in the form of a very delicate thread.\(^9\) The number of these tubes varies according to the species, the age, and the sex.\(^10\) Those belonging to the unbranched glands are distinguished from the others by their size. With some species of *Clubiona* and *Drassus*, there are, beside the usual six spinnerets, two others, composed of a single article and joined together. This fourth pair is situated on the belly, forward of the others, and is connected with a kind of comb (*Calamistrum*) attached to the metatarsus of the two posterior legs.\(^11\)

With *Phalangium*, there is an S-shaped glandular tube situated on the digestive canal, and ending at both extremities by a narrow duct. Its nature is yet unknown; and although the outlet of these excretory ducts has not been discovered, yet as this apparatus is found only with males, it may well be supposed to have some connection with the genital functions.\(^12\)

With some Acarina, there are certain phenomena indicating that these animals have special secretory organs, whose product, like the web-liquid, is hardened on its evacuation. Thus, with some species of the genus *Uropoda*, there is formed, by a substance of this kind, a peduncle situated at the posterior part of the abdomen, and by which these animals fix themselves to insects. This stalk, dilated disc-like, was taken formerly for an organ of suction.\(^13\) Many species of *Hydrachna* fix, by a kind of glue,

\(^8\) *Myzale* has only this one kind of glands; they form four groups, situated immediately at the base of the spinnerets.

\(^9\) The spinnerets and terminal tubes have already been very exactly figured by Leeuwenhoek (*loc. cit.*, p. 316, fig. 5, 6), and by *Roetel* (*loc. cit.*, Taf. XXXVIII, fig. 4). See also *Lyneot*, *loc. cit.* p. 387, Pl. XIX, fig. 6-12; *Wasmann*, *loc. cit.* p. 20, fig. 31-34, and *H. Meeckel*, *loc. cit.* p. 54, Taf. III, fig. 43-45.

\(^10\) There are more than a thousand of these tubes on the spinnerets of *Epeira*; with *Terecania*, there are about four hundred; with *Clubiona* and *Lycosa*, three hundred; with *Serestria*, one hundred, and their number is even less with the small spiders; see *Blackwell*, *Transact.* of the Linnean Soc., XVIII, 1844, p. 219, and *Ann. Nat. Hist.* XV, p. 221, and *Menge*, *loc. cit.* p. 34.

\(^11\) This pair of accessory spinnerets is found, according to *Blackwell* (*loc. cit.*), with *Clubiona atroz*, *Drassus viridis-limus*, *parcus* and *exiguus*.

\(^12\) See *Trevisanus*, *Verm. Schriff.* I, p. 37, Taf. III, fig. 17, h., and *Tulik*, *loc. cit.* p. 252, Pl. X. fig. 21.

\(^13\) See *Degeer*, *loc. cit.* p. 52, Taf. VII, fig. 16, and *Dugas*, *Ann. d. Sc. Nat.* II, p. 50 (*Urourpoda vegetans*). The peduncle is more or less long and often attached to the hardest parts of the Coleoptera. Its formation is connected with some metamorphosis of these animals, and is without doubt due to a secretion produced by some glandular apparatus opening near the anus. This view appears, at least, more natural than that advanced by *Dugas* (*loc. cit.*, p. 39), and adopted by *Desjardins* (*Compt. rend.* loc. cit. p. 1160), that this peduncle is formed by the feces hardening after their escape from the anus.
the anterior portion of their body on aquatic plants, and in this position, wait the completion of their moulting. The secreting organs of this substance have not yet been discovered.

CHAPTER IX.

ORGANS OF GENERATION.

§ 316.

All the Arachnoidae reproduce by a sexual generation, and their male and female genital organs are situated upon different individuals. The eggs are fecundated in the genital organs of the females, and the males have often copulatory organs of a very singular character. The Tardigrada form an exception in this respect, being hermaphrodites, and wanting the copulatory organs.

In general, the genital organs of the Arachnoidae are composed of the following parts. The ovaries or testicles are always double, but sometimes blended together on the median line. They are situated in the abdomen, and have two excretory ducts, which usually open at a common genital orifice at the base of the abdomen, or under the thorax. The ovaries, when filled with eggs, have always a botryoidal aspect. Only a few species have an ovipositor or a penis. The excretory ducts of both the ovaries and the testicles sometimes have appendages which, with the females, serve to receive the sperm, or to secrete a viscous substance for enveloping the eggs; and which, with the males, represent an epididymis or the seminal vesicles. Quite often, the males differ from the females in a special modification of their cheliceres, their palpi, or some of their legs. When this is the case, these organs serve, during copulation, to hold the females, or play the part of a penis.

The eggs of the Arachnoidae are spheroidal, rarely oval, and composed of a smooth chorion enclosing a vitellus consisting of vesicles filled with a colorless and, also, often highly-colored fat, in the midst of which is concealed the germinative vesicle. The germinative dot is sometimes simple, sometimes composed of a group of small granules. The eggs of *Lycoa*, *Thomius*, *Dionedes*, *Salticus* and *Tegenaria*, are remarkable; for, beside the germinative vesicle, they contain, before being filled with the vitellus, a peculiar, round, finely-granular, solid nucleus.

1. According to Dr. *Eisen* (Ann. d. Sc. Nat. L. p. 179), *Hydrachna coerules*, adult, before moulting, bores into aquatic plants by means of its oral organs. But I have seen it fixed, also, upon smooth glass walls, with the parts of its mouth enveloped in a kind of cement.

2. The eggs are oval with the *Oribatea* and *Scorpionidae*.


4. It is composed of a group of granules with *Epeira*, *Clubiona* and *Salticus*; see *Wagner*, *Prodom. de loc. cit. p. 8, Tab. 1 fig. 11 (Epeira).

5. This nucleus which appears to contain a central mucilus, is distinguished, with direct light, by its dirty-yellow color, and it has always appeared to me that there were detached successive layers from its surface several layers of granules which mixed with the albumen, without the nucleus diminishing in size. At all events, this nucleus plays an important part in the development of the eggs, for it appears very early, and does not disappear until quite late. It has also been observed

§ 316.
The lower Arachnoidae produce only a small number of eggs at a time, but these are often of a size disproportionately large to that of the animal.\(^4\)

As yet, only very incomplete researches have been made on the elements of the Spern. It appears, however, that the spermatic particles differ considerably in the various groups. Those of the Tardigrada have the cerarian form; those of the Scorpiionidae, on the contrary, are simply filamentoid. But both kinds have very active movements which are suspended by the contact of water.\(^5\) The Sperm of the Araneae always contains spherical or reniform motionless corpuscles.\(^6\) With the Acrina, the spermatic particles are motionless and of most varied forms.\(^7\)

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\(^{4}\) by Wittich (Observ. quaed. de Aranearum ex ovo evolut. Dissert. Halli, 1545, fig. 1, A.),\(^5\) See Doyere, loc. cit. p. 354, Pl. XVI. fig. 5 (Macrobiotus), and Kolliker, Schweiz. Denkschr. VIII. loc. cit. p. 25. Taf. II. fig. 10 (Scorpio enucleatus). I have observed that the characteristic movements of the spermatic particles ceased instantly from contact with water, and that the particles themselves became twisted and doubled.

\(^{5}\) With Tecevarina, Salticus, Lycosa and Thelazon, the spermatic particles have the form of round cells, while those of Microphantes and Clubiona are reniform or semicircular. They are formed in groups in the mother-cells. With Tegenaria, a round nucleus is easily distinguished in the spermatic particles. With Lycosa, this nucleus is oblong, curved and attached to the wall of the cell; and this led me at first to think these cells were the spermatic particles in their first stages of development, and that their definite form would be cerarian. But I quickly abandoned this idea when I found the same form in the seminal receptacle of the females, where, evidently, the spermatic particles cannot be present except in their perfect state.

\(^{6}\) With Trombidium, Zetes, Oribates, and Hoplophora, the spermatic particles are developed, as I have satisfied myself. The spermatic particles of the Hydrachnea and Gamases, I have observed round masses of caseiform bodies, at the larger extremity of which there was an oblong granular spot. We have also satisfied myself that these motionless spermatic particles of such large size are preceded in their development by round nucleated cells. In the testes of the Ixodes ricinus, I have seen countless transparent staff-like bodies, pretty long and large, motile, but swollen at one of their extremities when placed in water.

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\(^{7}\) \([\ S 316, \ note \ 3.\] The development and structure of the eggs of Araneae have recently been carefully studied by Wittich (Die Entstehung der Arachnidensäume in Eierstocke, die ersten Vorgänge in denselben nach seinem Verhältnisse des Nut- terkörpers; in Malte's Arch. 1849, p. 110, and by J. F. Carus (Ueber die Entwicklung des Syrinx, in Siebold and Köliker's Jahresb. II. 1856, p. 97). The structure of the ovary of these animals is no less beautiful than singular; it resembles a bunch of grapes enclosed in a common capsule. The eggs are developed each, on the extremity of a pedicle which is attached to the main stem or rachis. The details of the development of the egg are briefly as follows: On the extremity of the pedicle appears a delicate vesicle, or cell, which contains a nucleated cell. This nucleated cell is the germinative vesicle, with its dot, and does not increase so rapidly in size as the vesicle in which it is contained; but this last dilates and expands, and minute cells appear in the liquid, lying between its membrane and the germinative vesicle. These newly-formed cells constitute the vitellus; and when the ovum is completely formed, it consists of vitellus in which is concealed the germinative vesicle with its dot. In a word, the ovum is here formed as elsewhere, except that it is developed on the extremity of a pedicle. In regard to the peculiar bodies mentioned above by Siebold, as found in the vitellus, their presence and structure have been observed by both Wittich and Carus; they are composed of concentric layers around a nucleus. Of their nature and function nothing is known. — Ed.

\(^{7}\) \([\ S 316, \ note \ 7.\] I have studied the development and nature of the spermatic particles of the Araneae and Acroara, but with results different from those above mentioned. With the first of these, they are developed, as usual, in special daughter-cells, and invariably consist of an arcuate staff, to which is attached a short but very delicate tail; indeed, this tail is so tenuous that only the best and highest microscopic powers can bring it out. It escapes the watchful eyes of Wagner and Leuckart, and led them to adopt errone- ous views of the formation of these bodies (see Art. Semen, Cyclop. Amst. & Phys. fig. 374). With the Acrina, the particles have the same form and character, but are much more minute and difficult of examination. It would appear from the description given above by Siebold, that he must have taken for spermatic particles the peculiar granule-like bodies found in the sperm of the Araneae. These bodies are very hydroscopic, but are homogeneous, and although I could make out nothing further as to their structure, yet it is evident that they are wholly different from the true spermatic particles, and cannot be considered as either undeveloped or modified forms of these last. — Ed.
I. Hermaphrodite Arachnoidae.

§ 317.

The Tardigrada have only a single, but large, ovarian tube, applied on the posterior half of the digestive canal and opening into the cloaca. This last which is only a dilatation of the rectum, receives, also, two lateral, narrower, seminiferous tubes, together with the excretory orifices of a pyriform seminal vesicle. With *Milnesium*, *Eurydiun*, and *Macrobiotus ursellus*, the eggs are surrounded by a smooth chorion, and deposited in a solid epidermus which is detached during the molting.—so that all the eggs are finally contained in this envelope. But the other species of *Macrobiotus* shield their eggs in another manner, by surrounding each with a very solid, granular capsule.1

II. Female Arachnoidae.

§ 318.

The female organs of the Acarina consist of two ovarian sacs, the oviducts of which open in a common vulva situated in the middle of the belly, or further forwards on the thorax, sometimes between, sometimes behind the last two pairs of legs.2 With many of these animals, the oviduct opens into a protractile ovipositor by the use of which the eggs are lodged under the epidermis of plants or animals.2 A great number of Mites

1 For the genital organs of the Tardigrada, see *Duèvre*, loc. cit. p. 350, Pl. XIII. XIV. XVI. *Goeze* (Lomar). Abhandl. aus d. Insektn. 1773, p. 374, and O. F. *Müller* (in *Flacourt*). Arch. d. Insektenkunde, III. VI. p. 27, Taf. XXXVI. fig. 4, 6, had already observed that the Tardigrada deposit their eggs in their cutaneous envelope.3

1 With the Gymnosa, and Erodes, the vulva is situated on the thorax; while, with the Trombidia, Bdella, Hydrachna, and Oribatea, it is upon the belly; see *Treviranus*, Verm. Scrip. Taf. V. *Hydrachna* and *Trombidium*; Audouin, Ann. d. Sc. Nat. XXV. Pl. XIV.; *Müller*, Nov. Act. Nat. Cur. XIV. Tab. LVII.; and *Treviranus*, Zeitsch. f. Physiol. IV. Taf. XVI. fig. 2 (Ixeades). For the ovaries and oviducts of the Acarina, we have only the works of *Treviranus*, Verm. Schrift. I. p. 41 Taf. VI. fig. 32 (Trombidium), and Zeitsch. f. Physiol. IV. p. 190, Taf. XVI. fig. 7, 8, 10, 11 (Ixeades). I have observed with *Ixeades riciun* the following peculiarities, which were probably overlooked by *Treviranus* with *Ixeodes americanus*. The two long ovaries anastomose abruptly at the posterior extremity of the abdomen. The two oviducts, here given off, open right and left into a pyriform uterus whose neck communicates laterally with a large excretory canal coming from the vulva. This canal is divided by a septum into a posterior, or larger, and an anterior, or smaller, portion. The first receives the sperm which flows from the second during copulation, and thence passes into the uterus and even into the oviducts. The anterior portion represents the vagina properly speaking, and is in communication with two short cylindrical glands filled with transparent cells, and which secrete probably a substance for enveloping the eggs. I have, moreover, found with other Acarina (for example, with the Hydrachna, Gymnosa, and Oribatea) various organs belonging to the genital apparatus, but without observing their relations as clearly as with *Ixeodes*. However this may be, I am convinced that *Dugardin* (Ann. d. Sc. Nat. III. p. 39) goes too far in saying that, with most Acarina, the eggs are developed freely in the parenchyma of the body, without the necessity of an ovary with proper walls. According to this same naturalist (Ibid.), the Oribatea are viviparous and have a large vulva which can be closed by two lateral flaps, and before which is an orifice closed also by a similar apparatus. This last orifice belongs to a tube which *Dugardin* regards as a penis; so that the Oribatea would be hermaphroditic. As to the first point, — the viviparity of these animals, I have verified it for *Harpalus*, *Zetes* and *Oribateus*; but I cannot say as much of the second point, for, as I have satisfied myself, the posterior orifice is an anus, and the anterior a vulva having an ovipositor.


* [§ 317, note 1.] See also *Kaufmann* (loc. cit. in *Siebold* and *Kolliker's* Zeitsch. III. 1857, p. 220), who has studied the development of the eggs from their first stages, in the ovary of *Macrobius Dugardin*. — *Ep.*
surround their eggs, grouped together, with a tough coagulable substance, and glue them to various bodies. It is, therefore, very probable that there are special organs for the secretion of this substance. (3)

As yet, we have no observations on the internal genital organs of the Pycnochididae, although, for a long time, the females have been recognized by their filiform oöphores, composed of nine to ten articles, and situated in front of the first pair of legs. (4)

With the Phalangidaceae, the two ovaries are blended together, and form a flexuous tube occupying a large portion of the abdomen and continuous anteriorly into two short oviducts. These last unite in a large oviduct situated, loop-like, in the posterior extremity of the abdomen, between the convolutions of the ovaries. Its anterior extremity receives a second oviduct, which, after describing numerous convolutions, opens in a horny, articulated ovipositor. This last can be protruded between the posterior legs by means of a special muscular apparatus, on the under side of which are two cæca opening into the oviduct at the base of the ovipositor. These organs are either seminal receptacles, or the secretory organs of a viscous substance. (5)

With most Araneae, the two oblong ovaries are concealed between the hepatic lobes, and open by the intervention of two short oviducts, into a vagina situated between the two pulmonary sacs. This vagina is supported by a horny plate, and opens externally through a transverse fissure, after having previously received the excretory ducts of the two contiguous Receptacula semenis. These last are pyriform and nearly always composed of a deep-brown, horny substance; they are attached to the cutaneous envelope, and have, each, an equally horny excretory duct which is more or less long and interlaced with the corresponding one on the other side. (6)

The females surround their eggs in groups, with a web, so that they have no organs for secreting a viscid substance.

The Epeiridae offer a remarkable modification in their external genital organs. The entrance to their vagina is covered by a horny process, directed from before backwards, and at the base of which there are pyriform, pedunculated, seminal reservoirs. (7) It is yet undetermined whether this process is connected with the act of copulation, or with the deposition of the eggs.

The Scorpionidae have three ovaries consisting of as many longitudinal tubes united by four pairs of transverse ones. The two external of the former tubes are continuous anteriorly as oviducts, and unite in a short vagina which opens at the base of the abdomen. Before their junction, the oviducts dilate into a round pouch, which, as it sometimes contains the sperm, may be regarded as a Receptaculum semenis. (8)

3 For example, Eyllis, Limnochares, and Diploclavus.
4 See Johnston, Magaz. of Zool. I. p. 370; Pl. XIV.; Milne Edwards, Hist. Nat. d. Crust. Pl. XLI. fig. 7; and Philipp, in Wirzmann's Arch. 1843, I. p. 177, Taf. IX. With Ptoxichilium, the two oöphores are only five articulated.
5 See Treadus, Vers. Schrift. I. p. 34, Taf. IV. fig. 20, 21; also Tuck, loc. cit. p. 351, Pl. V. fig. 26-29.
6 Treadus (Bau d. Arachn. p. 37, Taf. IV. fig. 32) has figured very correctly the ovaries and their oviducts. He has even seen the Receptacula semenis, but he mistook them for carapaceous bodies (ibid. p. 38, Taf. II. fig. 29, a. and Taf. IV. fig. 40, o. 41). The anatomists who succeeded him paid no attention to these organs. The seminal receptacles are short and pyriform with Lycosa, Theridion, and Micryphantes; but they have a long excretory duct entwined with its opposite, with Drassus, Salticus, and Thomius.
7 This process is S-shaped with Epiria diadema. It has been described and figured by Lescuerbock, loc. cit. p. 330, fig. 8; Rosecr, loc. cit. p. 283, Taf. XXXVII. fig. 1, b. and Taf. XXXXVIII. fig. 1, 3; and by Deguer, loc. cit. p. 38, Taf. XII. fig. 10. See also, Treadus, Bau d. Arachn. p. 39, Taf. II. fig. 18, c.; and Savigny, Descrip. d'Egyp. loc. cit. Pl. II. fig. 9. With Nephila fasciata, this process is tongue-shaped.
8 The female organs of the Scorpionidae have been described by Meckel (Beitr. loc. cit. p. 113,
III. Male Arachnidae.

§ 319.

From the few observations hitherto made upon the male organs of the Aecaria, it appears that they are formed after very different types. With Trombidium, there are twenty red, testicular vesicles, attached by short peduncles to the annular Vas deferens which opens between the posterior legs. This last, before its termination, receives also two brown, long-pedunculated vesicles, whose nature is yet unknown. (1) With Ixodes, the testicles consist of a group of four to five pairs of longer or shorter follicles, which unite in the middle of the abdomen, and send off two small Vasa deferentia to the base of the chin-like process. This last, together with the cheliceres, these animals introduce deep into the vagina during copulation, while their two palpi, separated at a right angle, are applied upon the thorax of the female. (2) With Gamasus, there appear to be only two simple, isolated, testicular follicles, each having a deferent canal. With many Aecaria, there is a short penis situated at a point corresponding to that of the vulva of the females, and sometimes concealed within the body. (3) With other Aecaria, the males are distinguishable from the females, by the larger size of their cheliceres, and some of the legs which serve to retain the females during copulation. (4)

With the Phalangidae, the testicles consist of numerous small caeca, all united at one point into a long, flexuous deferent canal. This last is continuous into a Ductus ejaculatorius which traverses a muscular penis; this terminates with a hook-like gland, and its body is horny and surrounded by a muscular sheath out of which it can be protruded under the thorax. (5) With many Opilionina, the posterior legs have remarkable spines and excrences which, undoubtedly, are used during copulation. (6)

With the Araneae, the testicles consist of two long, simple, interlaced caeca, concealed between the hepatic lobes. (7) From them pass off two

Taf. VII. fig. 18-20); Treseisurus (Bau. d. Arach. p. 12, Taf. I. fig. 12), and Muller (loc. cit. p. 13 Taf. II. fig. 14-19). This last naturalist has found, with the large African scorpions, eggs in the lateral long, varicos and caecal appendages of the ovaries. These appendages do not increase in size except in proportion as the eggs are developed; while, with the small European scorpion, the eggs produce only simple pyriform folds on the ovarian tubes. I have seen spermat and very active spermatic particles in the seminal receptacles of living females of Scorpion europaeus.

I have proved this complicated disposition of the male organs with Trombidium holosomaticum, where it had been wholly misapprehended by Treseisurus (Vern. Schrift. L. p. 48, Taf. VI. fig. 35).

This singular mode of copulation had already been observed by Degeer (loc. cit. p. 43, Taf. VI. fig. 6) with Ixodes ricinus, and subsequently by Ph. W. J. Muller (Germ. Magaz. d. Entomol. II. 1815, p. 281) but it remained wholly unobserved by the other entomologists. It appears that the male of Ixodes ricinus, which differs considerably from the female, has been mistaken for a different species and named Ixodes reduxus (Audouin, loc. cit. XXV. p. 422, Pl. XIV. fig. 4), or Ixodes marginatus (Hehn, Die Arach. II. p. 63, fig. 150). The characters peculiar to this sex are, a
doral shield covering the whole body, palpi shorter, and roach less numerous upon the also shorter chin-like process.

3 The penis is sub-central with Bidella, sub-basal with Gamasus, and behind the genital orifice with Orithodes. With Arceurus, it is inserted on a tuberosity of the abdomen, giving the males a very singular appearance (Dugès., loc. cit. L. p. 156, Pl. N. fig. 20).

4 With the males of certain species of Gamasus, the two cheliceres are perforated, and the second pair of legs is very stout and provided with spines and excrences. With Dermauleichus, it is the third pair of these organs which is sometimes very large and armed with robust nails. With Surrogates, the posterior legs are long and armed with nails and disc, while with the females these same legs are abortive.

5 Treseisurus, Vern. Schrift. L. p. 56, Taf. IV. fig. 21, 22; and Talk, loc. cit. p. 250, Pl. IV. fig. 21-24.

6 With Eumurus, Gonyloptes, &c. The very large cheliceres of the Phalangidae are not used in the act itself of copulation, but are employed to fight with on these jealous occasions; see Latreille, Hist. Nat. d. Fourmis, p. 386.

deferent canals to the base of the abdomen where, between the two pulmonary sacs, there is a genital opening in a small horny plate. This opening is only a simple transverse fissure which, in copulation, does not come in contact with the vulva of the female. These animals always use their hollow, spoon-shaped palpi, which often have a very complicated structure. They are filled with sperm and applied to the entrance of the vulva. For this purpose, the last article of the palpi, which is always hollow and much enlarged, contains a soft spiral body terminated by a curved, gutter-like, horny process. Besides this, there is an arched, horny filament, and several hooks and other appendages of the most varied forms. These appendages are protractile, and serve, some to seize the female, and others as conductors of the sperm.\(^8\)

With the Scorpionidae, each of the two testicular tubes forms a loop enveloped by the substance of the liver, and connected with its mate by two transverse canals. The anterior border of each of these loops sends off a short Vas deferens which opens at the base of the abdomen, receiving in its track two ceca of unequal length. Of these, the longer contains a granulo-vesicular substance, and is, perhaps, an accessory gland; while the shorter, from the character of its contents, is evidently a Vesicula seminalis.\(^9\) A deeply crenated, small papilla projects out of the genital orifice, and, as it is wanting with the females, may be regarded as a

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\(^8\) For a long time, the excretory point of the Vasa deferentia was undetermined, because the two sexes of these animals had never been seen to place in contact these genital orifices during copulation. But when it was discovered that only the palpi of the males touch the vulva, the excretory ducts of the testicles were sought in these palpi. It is only recently, however, that it has been perceived, that with these animals, as with the Libellulidae (see my memoir in German's Zeitsch. L. d. Entomol. II. p. 453), the copulatory organ and the Vesicula seminalis are entirely removed from the male genital orifice. In order to be convinced that the application of the male palpi against the female vulva constitutes really the act of copulation, it is only necessary to examine the palpi under the microscope and compress them. From the last article a large quantity of sperm will soon be seen escape. Then again, after copulation, the Receptaculum seminalis of the females will be found filled with the fluid. The form of the palpi with the males varies almost infinitely according to the genera and species. They are very simple and slightly swollen with Clubiana and Lycosa, while, with Epeira, Tegenaria, Linychia, Micyphanes, Salticus, Argyroneta, &c., their last article is so complicated that the most minute description would be inadequate in giving an exact idea of it; see the figures of Lysonet, loc. cit. p. 383, Pl. XIX, XIX; Treviranus, Bau d. Arachn. p. 37, Taf. IV. fig. 35-37; Brandt, Medit. Zool. II. p. 87, Taf. XV. fig. 1; Snuytgh, Descrip. de l'Egypte, Pl. I.-VII.; Montre, loc. cit. p. 35, Taf. III. fig. 23-27. Treviranus (Bau d. Arachn. p. 35) has made an exposition of the older opinions of Lister, Lyonet, Clerck, and Deguer, on the copulation of these animals; but he regarded the act as only a prelude for exciting the sexual desires, and which would be followed by a real copulation, consisting of the contact of the male and female genital orifices. Moreover, Treviranus had never observed this last act. The more recent observers, such as Duval (Ann. d. Sc. Nat. VI. p. 187), Menge (loc. cit. p. 35), and Blackwall (Annals of Nat. Hist. p. 225), have naturally only confirmed the views of the older naturalists. According to Menge, the males of Linychia and Agelena evacuate a drop of sperm from their genital orifice, which is then received and absorbed by the last article of their palpi.\(^8\)

\(^9\) For the male organs of the Scorpions, which have been very imperfectly described by Treviranus (Bau d. Arachn. p. 22, Taf. fig. 11), see Michel (Beitrag. loc. cit. p. 114, Taf. VII. fig. 14), Serres (loc. cit. p. 89) and Maller (loc. cit. p. 59, Taf. I. fig 8). I have seen distinctively with living individuals of Scorpio europeus, spermatic particles in motion in the small ceca which I have called the seminal vesicles.

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\(^{[\text{§ 319, note 8.}]}\) I have made a microscopic examination of this curious palpus-structure in connection with the general structural relations of the internal genital organs, in some of the common Araneae (Tegenaria, Agelena, &c.) where this formation is most marked. In Agelena, the peculiar, cork-screw-like, horny process, situated in the last, spoon-shaped article of the palpus, contains a canal throughout, which commences in a kind of receptaculum at the base of the process. This receptacle is filled with the peculiar gramine-like bodies mentioned above (Note to § 316, note 7.). As the most repeated and careful examinations showed no spermatic particles in this palpus-capsule, I was led to advance the view that the palpi were only excitable and not intromittent organs, in the copulatory act (see Proceed. Boston Soc. Nat. Hist. IV. 1854, p. 106). But the question is still open, and especially as some recent investigators of the economy of these animals have observed facts that would indicate the intromittent function of these organs; see particularly, Blackwall, Ann. Nat. Hist. passim, for several years past. — Eb.
rudimentary penis. It is yet undetermined if the two external, lateral, pectiniform appendages situated near the genital orifice in both sexes, serve any purpose during copulation.\(^{30}\)

§ 320.

We have, as yet, only insufficient observations on the Development of the Arachnoidae. However, those that we possess upon its first stages,\(^{3}\) show that, with few exceptions,\(^{6}\) here as with the Crustacea, the disappearance of the germinative vesicle is followed by a superficial and partial segmentation of the vitellus. There is thereby formed a thin embryonic layer, composed of molecular corpuscles retained in a transparent viscid liquid, and distinguished from the rest of the vitellus by its white color. While this oval blastoderm, whose longitudinal axis corresponds to the ventral or nervous side of the embryo, extends towards the sides and the back, it divides into an external or serous, and an internal or mucous lamella, the last of which gradually covers the remaining portion of the vitellus, and becomes changed into the digestive tube and its appendages. In the mean while, there appear, on the external surface of the serous lamella, various symmetrical prominences and projections, which in time become the segments of the body, the parts of the mouth, the tactile, and the locomotive organs.

With the exception of the Scorpionidae, and Oribatæ, which are viviparous, the embryos of all the Arachnoidæ are developed subsequent to the deposition of the eggs.\(^{6}\)

With the majority of Arachnoidæ, the embryos, at their escape from the egg, have the form of the adult.\(^{6}\) The lower orders, only, form an exception in this respect, for they acquire their definite form after several moultings, and a true metamorphosis. With the Pycnogonidæ, these

\(^{30}\) *Twink* (Ann. of Nat. Hist. XV. p. 56) has lately expressed the opinion that these combs serve to clean the palpit, the tarsus, and the extremity of the full. He adds, as proof, the presence of transparent combs of exactly identical form, with *Obisium*, between the pincers of the cheliceræ, and which are used for this purpose.

\(^{5}\) The first planes of development have not been observed as yet except with the Araneæ and Scorpionidae; see *Herald*, De General. Araneæ, in ovo, 1824; *Kotthofer*, Zur. Morphol. Reisebesch. austriauriæ, 1837, p. 17, and in Burdach’s *Physiol.* II. 1857, p. 242; the same in *Frisier’s* neue Notz. XXIV. 1842, p. 165 (Lygosia suecata); also *Kuhlken*, in *Waller’s* Arch. 1845, p. 139 (Scorpio europaicus); finally, *Wittich*, Observ. quoad. de Araneæ, ex ovo evolut. Hallei, 1845, fig. 1, A. As to the development of the Acarina, I have satisfied myself upon the eggs of the Oribatæ, that the same phenomena occur as with most of the other Arachnoidæ.\(^{4}\)

\(^{6}\) I have distinctly seen, in the eggs of *Macrobiotus Huflandtii*, the segmentation involve the entire vitellus. *Kuhlken* (*Waller’s* Arch. 1845, p. 150) has made the same observation with *Pycnogonum.*\(^{3}\)

\(^{3}\) The relations of the Scorpionidae in this respect are very remarkable, for their embryos are developed in the ovaries at the spot even where the eggs are formed; see *Waller*, loc. cit. p. 55, and *Kuhlken*, Zur Morphol. loc. cit. It is evident that the sperm must ascend from the two seminal reservoirs into the ovaries to fecundate the eggs. With the Oribatæ, the embryos appear to be developed in a kind of uterus situated immediately behind the ovipositor.

\(^{4}\) With the Araneæ, the sexual differences which are so striking do not appear until after the first molting.

\[^{\text{[6320, note 1]}}\] See, also, *Wilson*, Researches into the structure and develop of a newly-discovered parasitic Animalcule, &c., in the Philos. Trans. 1844, p. 505 (*Entosoma Domodeo* folliculiferum), and *Van Beneden*, Recherches sur Faiax apalicorn, in the Mem. de l’Acad. Roy. de Brussels. XXIV. *Wilson’s* details are imperfect, and throw but little light on the real character of the development of the follicle-parasite. It would appear, however, to be truly one of the Arachnidae. — *Ed.*

\[^{\text{[6320, note 2]}}\] For the embryology of the

Tardigrada, see *Kaufmann*, loc. cit. in *Siebold* and *Kuhlken’s* Zoösch. III. 1861, p. 220. The type of development is like that of the Articulata in general, and this would seem to clearly settle the position of these animals in this class. *Kaufmann* confirms the observation of *Siebold* as to the segmentation of the entire vitellus. After this process has occurred, the mulberry-like mass is changed into the embryo, exactly as is observed with the eggs of the Arachnoidæ in general. — *Ed.*
§ 320. THE ARACHNIDAE.

changes should be most prominent, for their embryos have a short unarticulated body, and, beside the chelicerae, are provided with only four bi-or tri-articulated feet. There is, however, a very long lash, attached, sometimes to the two chelicerae, sometimes to each of the four legs. It is not until after successive moultings, that the other legs, the divisions of the body, and the extremities, appear. (5)

With Eumylium, (6) and most of the Acarina, the embryos have only six legs, when hatched; but as they otherwise resemble the adults, their metamorphosis consists only in the appearance of another pair of legs. A true metamorphosis is observed only with Hydrachna. Here the embryos have a very long and large snout which might easily be taken for a head distinct from the trunk. (5) This disproportion between these two parts is subsequently reversed, when the young pierce with their snout the bodies of insects, while their own bodies, gorged with food, become of a monstrous size. These young have six legs, and, during their parasitic life, were for a long time described as distinct species under the generic name Achly sia, until it was discovered that they possessed eight legs after their first moulting. (5) Similar metamorphoses occur with the Trombidia which, as red, hexapod larvae, are attached to flies, grasshoppers, plant-lice and various other terrestrial insects. These, also, have been formed into proper genera under the names of Astoma, Leptus, and Ocypeta. (6) *


5 See Dugès, Ann. d. Sc. Nat. I. p. 166, Pl. XI. fig. 47. It follows clearly from the position of the eyes, which are situated not upon this snout, but upon the cephalothorax, that this snout is only a support of the parts of the mouth, and not a head.

6 See Audouin, Mém. sur l'Achlyse in the Mém de la Soc. d'Hist. Nat. de Paris, I. p. 88, Pl. V. No. 2). He found these red Achly siae with monstrous bodies on the dorsal surface of the abdomen of Ogitinus and Hydrophillus. Others, smaller, were observed even more frequently upon the segments of the body and the articles of the extremities, with Nepe, and Rana troa. The true nature of these epipsa has been cleared up by Burmeister (Isis, 1834, p. 138, Taf. I. fig. 1-6), and by Dugès (Ann. d. Sc. Nat. I. 1834, p. 166, Pl. XI. fig. 49-53).

9 See Gerovis, in Watkewaer, Aptères, &c., III. p. 173.

* [§ 320, end.] There is some ground for the opinion that alternation of generation, so called, occurs with some of the Arachnidae. Djufjardin (Ann. d. Sc. Nat. 1849, XI. p. 245) has examined the wall-mite found on the house and other flies — the Acarus muscorum of Deever, and the Hypopus of Dugès. It has neither mouth nor digestive apparatus, but simply adheres to the animal on which it lives, by a sucker. It may be the nurse of a Gamasus? — Eu.
BOOK FOURTEENTH.

INSECTA.

CLASSIFICATION.

§ 321.

As anatomists have been able to examine, with few exceptions, nearly all the orders and families of the Insecta, their anatomical researches have not been restricted, as in the preceding classes, to isolated genera or species, but have embraced entire families. With such abundant materials, we should go beyond the limits of our work in enumerating here all the genera, or even all the families, whose organization has been studied.

A. Insects without Metamorphosis.  
(Insecta ammetabola.)

ORDER I. APERTA.

Families: Pediculidae, Nirmidae, Poduridae, Lepismidae.

B. Insects with incomplete Metamorphosis.  
(Insecta hemimetabola.)

1. Mouth Suctorial.

ORDER II. HEMIPTERA.

Families: Cocidae, Aphididae, Psyllidae, Cicadidae, Cercopidae, Naucoridae, Nepidae, Coreidae, Pentatomidae.

2. Mouth Mandibulate.

ORDER III. ORTHOPTERA.

Families: Physopoda, Forficulidae, Psocidae, Perlidae, Ephemeraidae, Libellulidae, Termitidae, Acrididae, Locustidae, Achetidae, Phasmidae, Mantidae, Blattidae.
C. Insects with complete Metamorphosis.

(Insecta holometabola.)

1. Mouth Suctorial.
   a. Two wings. Under lip changed into a suctorial organ.

ORDER IV. DIPTERA.

b. Four scaly wings. Maxillae changed into a suctorial organ.

ORDER V. LEPIDOPTERA.
Families: Tineidae, Pyralidae, Geometridæ, Noctuidæ, Bombycidae, Hefiolidae, Zygaenidae, Sphingidae, Papilionidae.

c. Four naked wings. Tongue changed into a suctorial organ.

ORDER VI. HYMENOPTERA.

2. Mouth Mandibulate.
   a. Two posterior wings only.

ORDER VII. STREPSIPTERA.

b. Four membranous wings.

ORDER VIII. NEUROPTERA.
Families: Phyrganidae, Sialidae, Hemerobidae, Myrmeleonidae, Rhaphidiidae, Panorpidae, Mantispidae.

c. Two upper wings corneous, and two under membranous.

ORDER IX. COLEOPTERA.
Families: Pselaphidae, Coccinellidae, Chrysomelidae, Cerambycidae, Curculionidae, Cistelidae, Meloidæ, Tenebrionidae, Pyrochroidæ, Elateridae, Lampellicornes, Clavicornes, Hydrophilidae, Hydrocanthari, Staphylinidae, Carabidae.
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§§ 322, 323.

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Leidy. Die Dotterfurchung nach ihrem Vorkommen in der Thierwelt und nach ihrer Bedeutung, in the Isis. 1848, Hft. 3.


— Anatomisches und Histologisches über die Larve von Corethra plumicornis, in Ibid. III. 1852, p. 435.


See, also, the various writings referred to in my notes. — Ed.

CHAPTER I.

EXTERNAL ENVELOPE AND CUTANEOUS SKELETON.

§ 322.

The cutaneous envelope of the multi-articulate body of the Insecta consists, as with the other Arthropoda, of a kind of external skeleton, of a consistence sometimes leathery and soft, sometimes horny and solid. Its elasticity and flexibility is limited to the points of junction of the segments of the body, and of the articles of the extremities. Its characteristic chemical substance is likewise chitine, a peculiar azotic matter insoluble in caustic potass, and with which highly-colored pigments are often chemically combined.1 Chitine enters also into the composition of the hairs and the scales of the skin, and the internal processes which may be regarded as an Internal Skeleton.

§ 323.

Histologically, the cutaneous envelope is so variously and often so ex-

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1 See Odier, Mém. de la Soc. d'Hist. Nat. de Paris, I. loc. cit.; Lassaigne, Compt. rend. XVI. 1845, p. 1087, or Forriez's neue Notiz. XVII. p. 7, and Schmidt, Zur vergleich. Physiol. d. p. 32. Lassaigne has proposed for this substance the name Entomoderm. The coloration of the cutaneous skeleton is probably due to an ell with which the chitine is impregnated, especially with the Coleoptera.


* [§ 322, note 1.] Recent researches have shown that the peculiar substance Chitine is not limited in its distribution to the Arthropoda, for it has been found in nearly every class of the Invertebrata. See Grube, Muller's Arch. 1848, p. 491, and Wiegmann's Arch. 1850, p. 283; Schultze, Beitr. zur Naturgesch. d. Turbellarien, p. 33; and Leweart, Morphot. der wirbellosen Thiere, p. 49, in Siebold and Killiker's Zeitsch. 1851, p. 192, and in Wiegmann's Arch. 1852, p. 22.—Ed.
traordinarily complicated, that it is very difficult to recognize its elements. When horny, there can always be distinguished an epidermis composed of unucleated, lamellated cells intimately blended together. These cells, however, are often polyhedral, and so disposed as to form a simple layer; in other cases, they are more or less blended together, giving rise to undulating or imbricated lines in the epidermis. In order to study the subjacent layer, or dermis, the cutaneous envelope must be macerated and decolored in caustic potass. This layer will then be found to be composed usually of several lamellae superposed in various ways and thereby often producing very elegant markings. In many instances, these reticulated or radiated markings would indicate the presence here of intercellular passages, and porous canals.\(^1\) In the thin, membranous portions of the skeleton, for instance, the wings, the structure usually appears wholly homogeneous.

On the external surface of this envelope there are on numerous excrescences, such as tubercles, spines and hairs, which are usually hollow. The hairs are sometimes simple and smooth, sometimes set with small hairs or barbellate.\(^2\) Many of these cutaneous formations are inserted by a small peduncle in small fossae, to which they loosely adhere, and from which they are very readily detached. Usually, they are flattened, scale-

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\(^1\) Histological researches upon the cutaneous skeleton having as yet, been extended over only a few species. I am able to cite only the works of H. Meyer (Müller’s Arch. 1842, p. 12 (Lucanus cervus), and of Platten (Ibid. p. 38, Taf. 111. (Bombyx mori).

\(^2\) These barbellate hairs are found with the larva of all the Bombyciidae (Reinwardt, Mon. Re. Tom. I. Pl. VI., and Degeer, Abhandl. I. Taf. IX.—XIII.).

They are easily rubbed off, and when brought in contact with our skin, they instigate themselves by the trunctated extremity, and thereby often provoke an insupportable itching or even an inflammation. The processory moths are so much feared in this respect as to pass for being poisonous; see Nicolai, Die Wander- oder Processionsschabe, 1833, p. 21, and Ratzeburg, De Forsinsecten, 11. p. 127, Taf. I. fig. 12, and Taf. VIII.\(^{1}\) The paths which these hairs can produce with man, may be judged by the disease which Ratzeburg suffered, and of which he has given an account (Entom. Zeit. 1846, p. 35).

The symptoms spoken of by this excellent entomologist, may be explained without attributing any specific poisonous property to these hairs, if it be considered that, like a fine powder, they rest on the skin and may enter the respiratory organs by inhalation, and penetrating the tissues encounter a multitude of nervous fibres. Their passage into the tissues is the more easy, since they areuniform, very sharp at both extremities, the free one of which is provided with denticulations pointing upwards, while the opposite one is loosely inserted in a small fossa, so that they are detached without breaking from their fastenings by the least contact. The deep-colored spots observed on the back of the processory moth, and which are divided into four parts by crucial lines (Ratzeburg, Die Forsinsect, loc. cit. Taf. VIII., fig. 1.4 and 1. 9), consist of calcotics on which are situated thousands of these small fossae from which arise an infinite number of hairs. With many birds and insectivorous reptiles, the hairs of the moths which these animals have eaten, traverse the mucous membrane of the stomach and enter the tissues. I should not have thus mentioned this subject, since for a long time the true nature of the hairy stomaehs of old cuckoo has been understood (see the discussion on this subject between Brehm, Richter, Curtius, Oken, and Kruch, in the Isis, 1823, p. 222, and 666, Taf. VIII., also, 1825, p. 519, Taf. IV.), if, recently the passage of hairs from the digestive tube into the mesentery of frogs had not given rise to a similar error. The mesentery of these reptiles very often contains fragments of hairs and the spines of insects, surrounded by concentric layers of connected tissue and thus arrested in their course. These encysted hairs have been described by Remak (Müller’s Arch. 1841, p. 451) under the name of parasitic entomological hairy fibres, while Mayer at Bonn has gone so far as to take them for Pauicinian corpuscles (Die Pauicinischen Körperehen, 1844, p. 14, fig. 2).\(^2\)

\(^{1}\) [§ 323, note 2.] Will (Schleiden and Freyreg’s Nat. 1841, Aug. p. 143) has made chemico-microscopical investigations upon the nature of this peculiar poisonous power manifested in the processory moths; his researches were upon Bombyx processionena. The poisonous material was found to be formic acid in a free and highly-concentrated state; it was met with in all parts of the caterpillar, but especially in the exces, in the greenish-yellow liquid emitted by these animals when di-vided, and in the hairs. These hairs were mostly hollow, and their cavity was not closed at their base, but passed through the skin and appeared connected with glands below. These observations are the more interesting since this same observer has shown that the poisonous material of the poison-apparatus of the Hymenoptera, consists likewise of formic acid. See my note under § 347, note 11. — Ep.
like, and colored. Their forms vary infinitely not only according to the species, but also according to the regions of the body. They are often ribbed longitudinally, and denticulated or deeply serrated on their borders. These scales are often inserted on the skin perpendicularly, thus forming a petal-like covering easily wiped off; sometimes they are imbricated and exactly fitted to each other.\(^3\)

\[\text{§ 324.}\]

The various parts of the cutaneous skeleton of the Insecta have been so carefully studied in Zoology, that they may well be passed over here. As the internal surface of this skeleton furnishes points of insertion to the voluntary muscles, the segments of the body on which these last are attached, would naturally be developed in proportion to their volume. Thus with those Insecta which have powerful masticatory organs, the head is remarkably large on account of the prominent development of the masticatory muscles; in the same way likewise other fossorial, rapacious, or saltatory Insecta indicate their habits of life by the size of their legs, which are endowed with great muscular power. It is for the same reason, also, that with the species which fly, the mesothorax and metathorax are so largely developed; for these contain not only the muscles of the last two pairs of legs, but also those of the wings. These relations are especially distinct in those families or genera which embrace both winged and unwinged species.

On the internal surface of the cutaneous skeleton, are found, in the head and thorax, processes which may be regarded as an internal skeleton Some of these serve as septa, which separate certain organs, and others furnish points of insertion to muscles, and then are often bifurcated.\(^3\)

\[\text{CHAPTER II.}\]

\[\text{MUSCULAR SYSTEM AND LOCOMOTIVE AND SONIFEROUS ORGANS.}\]

\[\text{§ 325.}\]

The muscular fibres of the Insecta are striated, not only in the voluntary muscles, but often also in those of organic life, as in the stomach and intestine.\(^3\) All are colorless or of a dirty yellow color. This last is especially observed with the muscles of the thorax belonging to the wings, which differ,  

\(^3\) This covering has a velvety aspect with the Lepidoptera, Anthrarchidae, and Bombylidae; it is scaly on the bodies of many of the Cuculonimidae, Melanostichidae, Clavicorinae, Lepismidae, Podaridae and on the wings of the Culicidæ, and Lepidoptera. It has always excited the attention of naturalists, who have figured it in their works. See also Réaumur, and Deguer, loc. cit., also Luponct, Mém. du Muséum, XX. p. 82, Pl. VI—XI; Bernard—Deschamps, Ann. d. Sc. Nat. III. 1835, Pl. III. IV.; Ratzburg, Die Forstinsek. II. Taf. 1.; Dujardin, Observ. au microscop. p. 121, Pl. VII. IX. XI. XII; Nicolet, loc. cit. p. 22, Pl. II. (Podaridae), and H. Fischer, Isis, 1846, p. 401, Taf. IV. (Coleoptera).

\(^1\) For the internal skeleton of the Insecta, see Audouin, Ann. génér. d. Sc. physiq. VII. p. 182, or Meckel's deutsch. Archiv VII. p. 438; Eschenholtz, Isis, 1822, p. 52; Burmeister, Handb. &c. I. p. 251, and Newport, Cyclopaed. loc. cit. II. p. 969.

\(^2\) Necrophorus.
furthermore, from the others, in their transverse striae being less distinct, and their fibrillae being more easily observed; indeed, with most species, these last show a tendency to separate even from the least pressure, while those of the other voluntary muscles are very compactly united together.\(^{(2)}\)

The muscles are attached directly upon the cutaneous skeleton, as with the Crustacea. In the extremities, only, do there appear to be tendons; but these are merely very long, flattened processes of the skeleton, situated in the axis of the articles of the extremities. They serve as points of attachment to short muscular fasciculi which are there obliquely inserted, after having arisen from the inner surface of the articles. With adult insects, the segments of the body are only slightly movable, and have but few muscles. But with the larvae, whose extremities are rudimentary, or even wholly wanting, there is a very prominent muscular system situated directly beneath the skin, and composed often of several layers of flattened fasciculi.\(^{(2)}\)

### § 326.

The Locomotive organs, properly speaking, of the Insecta, are the legs and the wings. The true legs never exceed three pairs, and are inserted upon the first three segments back of the head — Prothorax, Mesothorax, Metathorax. Each leg is divided into a Coxa, a Trochanter, a Femur, a Tibia, and a Tarsus. The tarsus is divided into several articles, the number of which reaches even five. The form of these legs varies infinitely according to the mode of life of each species. The most common are those to which are usually given the names: Pedes cursorii, ambulatorii, gressorii, Straus, Consid. &c. p. 110, Pl. III. IV. (Melanontha vulgaris).

Reference may be also made to the works of Meckel (System, &c., III. p. 22), Cuvier (Legum., &c. II. p. 207), Burmeister (Handb. &c. I. p. 249), and of Newport (Cyclopaed. &c. loc. cit. p. 938).

* [§ 325, note 2.] The delicate and beautiful structure of the thoracic muscles of some of the Insecta, has been carefully studied of late, and has added not a little to the elucidation of the histology of the muscular tissue. See Lébert, Recherches sur la formation des muscles, &c., in the Ann. d. Sc. Nat. XII. 1830, p. 182-195, Pl. VII. fig. 18-27; but especially Lébert, Uber die eigen tümliche structur der Thoraxmusculen der Insecten, in Stiebold and Kulliker's Zeitsch. IV. 1855, p. 388.

This last-mentioned naturalist states that he has observed a new form of muscle-element in the thorax of the Libellulae, consisting of primitive muscular bands by means of which, with a beaker-shaped apparatus, the wings are moved. These fibres consist of flattened ribbon-like bands, situated on their borders as well as on their flat surface.

I have recently studied the elements of the thoracic muscles of many Diptera (Culic., especi

\(^{(2)}\) This is so with the Diptera, Hemiptera, and Hymenoptera, with the muscles of whose wings the elements may be very easily separated.\(^{(2)}\)

\(^{(2)}\) Lyonet (Tralite, &c., p. 114, Pl. VI.-VIII.) has given a very detailed account of the muscles of the larva of Cossus. See also Newport, Philos. Transact. 1836, p. 537; Pl. XXVII. (the cutaneous muscles of the larva of Sphinx ligustri), and
natatorii, saltatorii, raptorii, and fossorii.\(^{(5)}\) The tarsal articles are often enlarged, in which case they form, on their under surface, either a naked, fleshy sole, or a thickly-pilose ball of the foot, which is usually cordiform. With the Dytiididae, several of these tarsal joints are changed into a disc provided with suckers. The last article of these organs bears usually two movable hooks, which are sometimes deeply bifid or denticulate on their concave border.\(^{(7)}\) It is rare that there is a third hook between them.\(^{(8)}\) But with the Strepsiptera, and Physopoda, all the hooks are wanting. The Diptera and many Hymenoptera, have, moreover, under these hooks, soft lobules (Arolia) provided with numerous small papilae, by means of which these insects can fix themselves to objects.\(^{(6)}\) With a great number of larvae, the six legs are very short or abortive, or even completely wanting. In the first case, they consist, usually, of merely a hook, but these larvae have also many short obtuse processes on the other segments of the body, and by means of the hairy soles on the extremity of these, they can fix themselves on bodies and thereby move along.\(^{(5)}\) With many entirely apodal larvae, these processes are replaced by simple tubercles, or by belts of backwards-pointing bristles or spines, which serve as points of support in their locomotion.\(^{(6)}\)

The organs of flying are the anterior and the posterior Wings. The first are inserted on the mesothorax, and the second on the metathorax; but in nearly all the orders, there are genera with which these organs are wholly wanting.\(^{(7)}\) In other genera, the females alone are wingless,\(^{(8)}\) which is also true of the neuters of certain families.\(^{(9)}\) It is more common still, to see the posterior wings changed into balancers;\(^{(10)}\) and this same transformation occurs also, but very rarely, with the elytra.\(^{(11)}\) The wings, properly speaking, are only prolongations of the cutaneous skeleton traversed by tracheae and blood-canals. Their forms, their nerves, their folds, &c., as well as their sometimes complete abortive condition, may here be passed over, for all these points belong to the domain of Zoology.\(^{(6)}\)

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1 For the marching, leaping, and swimming of insects, seeStraus, Considérè, &c. p. 180.
2 Thus, the hooks are bifid with Meloe, and dentiform with the Pomphilidae, Hippoboscidae, Chilidae, and with Taphria, Dolichus, Calathus, and Pantophonus, of the Carabidae.
3 This third hook is found, for example, with Lucanus cervus. With larvae of the Meliaceae, the legs are terminated by three very remarkable, straight, lanceolate hooks, known by the name of Triangularus. Many of the Currenilidæ can grasp objects by means of the immovable hooks on their tibiae.
4 The Tenthredinidae have a lobule of this kind on each of their legs, and the Diptera have even two to three. For these lobes, as well as for the tarsi of Insecta in general, see the beautiful figures given by Everard Home (Lectur. on Comp. Anat. IV. Pt. LXXXI.-LXXXIV.). According to Blackwall (Trans. of the Linn. Soc. XVI. p. 457, 77; and Ann. of Nat. Hist. XV. p. 119), the papilæ of the Arolia secrete a viscid substance which enables the Insecta having these organs to walk on steep and smooth surfaces. But this assertion requires further proof, although it is admitted by Spence (Trans. of the Entomol. Soc. IV. p. 18).
5 With the Lepidoptera, and Tenthredinidae.
6 With many Diptera.
7 Among the Orthoptera, the wings are wanting with some Blattidæ, Acrididæ, Phasmidæ, and Psocidæ; among the Hymenoptera, with Acanthidæ, and Rhizobius; and among the Diptera, with Melophagus, Pilhiridium, and Pulex Angelinos.
8 With Lamprisa, some Blattidæ, Cocidæ, Bombycidæ, Geometridæ, also with the Mutilidæ and the Strepsiptera.
9 With the Formicidæ and the Termidæ.
10 With the Cocidæ and the Diptera. The posterior wings are entirely wanting with some Epheméridæ.
11 The two singularly distorted balancers of the Strepsiptera, situated in front of the wings and in rapel and unceasing motion, are, from their insertion, only abortive elytra.

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The movements of the wings are produced by two extensor and several smaller flexor muscles, which arise from the middle and posterior thoracic segments, and are inserted on a tendinous process at the base of each wing. The size of these muscles is proportionate to the size of the wings and their mode of use in flight. They are, consequently, all equally developed when the four wings participate equally in the act of flying, as is the case with the Lepidoptera, Hymenoptera, the majority of the Neuroptera, the Libellulidae, Perlidae, and finally, the Cicadidae, and the Aphididae.

The muscles of the anterior wings are comparatively smaller than those of the posterior, when the first are not used, properly speaking, except to cover the latter, as is the case with the Coleoptera, the Bugs, and many of the Orthoptera. With most of the Poduridae, and with the young larvae of Xenos sphecidarum, there is a peculiar, fork-shaped, saltatory organ. It is inserted on the posterior extremity of the body or under the abdomen, and, when at rest, points horizontally backwards. By means of a special muscular apparatus, this fork is bent forwards and applied against the abdomen; it is then returned violently into its original position, thereby tossing the animal a considerable distance. [12]

§ 327.

Many of the Insecta produce sounds which we perceive partly as clear tones, and partly as confused noises. These are due, sometimes to particular soniferous organs, but more often to vibrations of the cutaneous skeleton produced by special muscular organs, or to the rubbing of certain parts against each other. But in every case, without exception, the sound is due to the action of voluntary muscles, and has no connection with the respiratory organs. [1]

The buzzing produced by many Diptera, and Hymenoptera, during flight, is due, without doubt, to vibrations of the thorax produced by the rapid and successive contractions of the muscles of the wings in this act. [2] Further researches are necessary to show if the sounds produced by certain butterflies are due to rubbings of some parts of the cutaneous skeleton, or to a special soniferous apparatus. [3] But the sharp sounds of many Coleoptera

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12 For the flight of Insecta, see Straus, Consider. &c. p. 200; but especially the extensive work, illustrated with many figures, of Chabrier, Mém. du Muséum, VI.—VIII.
13 See Nicollet, loc. cit. p. 39, Pl. III.; and my Beiträgi, sur Natures d. wirbelt. Thierr. p. 84, Taf. III. fig. 70. This fork is wanting in the genera Achorutes and Anurophorus, as well as with the larva of Stylops among the Strepsiptera.
1 Some Insecta produce sounds by striking or rubbing certain parts of their cutaneous skeleton against the body. The males of Mastformula curculionoides knock with such violence the extremity of their body against the boughs on which they have alighted, that they produce a pretty loud sound, described, probably, to call the females. The larva of Vespera erubru, when hungry, scratch the walls of their cells with the point of their jaws, and thus call the attention of the parents to their condition.
2 The buzzing of these Insecta has been attempted to be explained in various ways. At all events, it cannot be due alone to the movements of the wings, for it persists sometimes after the removal of these last. Neither can it be attributed to the rapid passage of air through the stigmata of the thorax, causing vibrations in that part of the body. Bürmeister, who has advocated this last opinion (Handb. &c. I. p. 268, and in Poggen-dorf's Ann. d. Physik. XXXVIII. 1836, p. 253, Taf. III. fig. 7—9), compares these sounds to those produced by a siren; but this theory has been fully refuted by Gourow, Solier, and Erickson (see Siffermann's Revue Entomol. III. p. 165, and Ann. de la Soc. Entom. de France, VI. 1857, p. 31, and Wiegmann's Arch. 1828, II. p. 193). The various sounds of flies and bees may be imitated, moreover, by placing a vibrating tuning-fork in contact with a band of stretched paper,— an experiment in which the vibrations of the air take no part.
3 It is said that, with Emprega palda, the peculiar sounds are produced by the rubbing of a callosity of the two posterior lips against the middle lips (Solier, Ann. de la Soc. Entom. loc. cit.). The cry of Acherontia atropos has been attempted
are caused by the rubbing of their prothorax against the peduncle of the mesothorax, or by grating the ridges of the abdomen against the internal surface of the elytra. *Redeius stridulus*, *Mutilla europaea*, and *Mantis religiosa*, produce also certain sounds by the friction of particular portions of their skeleton. The males of many Acrididae produce their creaking sounds by playing, as with the bow of a violin, upon the lateral borders of their elytra, by their posterior thighs which have a longitudinal granular ridge on their internal surface. The peculiar cry of the male Locustidae and Aechetidae is produced by the base of their elytra. The very hard and sharp internal border of one of these elytra rubs against a horny ridge upon the under surface of the other, close to the tympanitic disc.

With the males of the musical Cicadidae, there is a very remarkable sonorous apparatus, situated on the under surface of the first abdominal segment. It consists of two spacious drums at the base of which is a dry, plicated membrane, to which is attached a large muscle of conical form, arising from a median, bifurcated process of the second abdominal segment. The entrance of each of these drums is more or less covered by a rounding operculum which is free behind. The muscle draws the membrane inwards, then relaxing, this last returns by its own elasticity, producing, as from the bending up and down of a metallic plate, a loud,clangling sound. This sound is undoubtedly considerably increased by the resonance of the air in the drums and in the neighboring vesicular tracheae.

6 For this sonorous apparatus, see Goureau and Solier, Ann. d. la Soc. Entom. 1837, p. 31; Newport, Cyclopaedia, loc. cit. II. p. 928, fig. 394–396; Goldfuss, Syst. ad. Orthop. quarund. ornitholog., Bonn. Diss. 1845, p. 5, fig. 1–10; and my observations in Wiegmann’s Arch. loc. cit. p. 63. Burmeister (Handb. &c. l. p. 511) has sought to explain this sound by referring it to the powerful escape of the air from the stigmata of the Locustidae and Acrididae; but this is unsatisfactory.

7 For the sonorous apparatus of the musical Cicadidae, see Réamur, Mém. V. 4th Mém. Pl. XVII.; Burmeister, Handb. &c. l. p. 515; Ratzeburg, Mediz. Zool. II. p. 208, Taf. XXVII; and especially Carus, Analek. zur Naturwiss. p. 142, fig. 1–18.4

9 [§ 327, note 3.] Haldeman (Silliman’s Journ. May, 1848) states that Lithobius minoris, Kirby, or an allied species, produces an audible stridulation by vibrating the pleura beneath the wings, this part being marked in recent specimens by parallel lines, apparently indicating the position of the muscles. According to him, it is possible that the European *Acherontia atropos* may produce its peculiar sound in a similar manner. — Ed.

1 [§ 327, note 7.] See also my investigations upon this apparatus of the *Cicada septendecim* in the Proceed. Boston Soc. Nat. Hist. 1831, p. 72. — Ed.
CHAPTER III.

NERVOUS SYSTEM.

§ 328.

The central parts of the nervous system consist, with the Insecta, as with the other Arthropoda, of a Brain and a Ventral Cord.\(^3\)

The brain is situated in the cephalic segment, and is composed of a Ganglion supraoesophageum, connecting with a Ganglion infraoesophageum which is smaller, by two lateral commissures which embrace the oesophagus. The first of these ganglia corresponds to the cerebrum of the Vertebrata; and the second is comparable perhaps to the cerebellum or spinal cord.

The ventral cord succeeds upon the sub-oesophageal ganglion, and consists, sometimes of a single ganglionic mass, sometimes of a chain of ganglia more or less approximated and connected by double, longitudinal commissures.\(^4\) The number of the ventral ganglia, which is never greater than that of the segments of the body, as well as the presence and length of the longitudinal commissures, depend often upon the number, the size, and the mobility of the segments of the body to which they belong. With those Insecta whose segments are very short and rigid, the ganglia are closely approximated or even entirely blended together; while, in most larvae, where the segments of the body are equally developed and flexible, the ganglia are separate, nearly equal in size, and connected by pretty long commissures. These last are rarely united into a single cord, although the ganglia, not only those of the ventral cord, but also those of the brain, appear, nearly always, to be composed each of two united ganglia.

Aside from the differences presented according as the insect may be a larva, a pupa, or an imago, the nervous system varies so much even in the same group, that it may be quite dissimilar in species which, in other respects, are very closely allied. These modifications refer to the number of the ganglia, the length of their commissures, and the more or less complete fusion between certain ganglia.

The superior cerebral ganglion, which is often composed of two hemispheres more or less fused together, gives off the two antennal and the two optic nerves. The simple eyes or stemmata, either when alone, or when coexistent with compound or faceted eyes, always receive their nerves from the same ganglion; although these last are sometimes given off from a trunk in common with the optic nerve. The sub-oesophageal ganglion furnishes nerves chiefly to the mandibles, to the maxillae and their palpi. With the perfect Insecta, the three thoracic are much more voluminous than the abdominal ganglia. They send nerves not only to the legs, but also to the muscles of the wings.


2 Entomonomists are not agreed as to the number of the abdominal ganglia, for the sub-oesophageal ganglion is sometimes regarded as the first of the ventral cord. For the nervous system of the larva and pupa of Sarcophaga, see L. Dufour, Rec. cit. Pl. I. fig. 12-15.
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The ventral ganglia are usually small, coarsely, and give off no nerves except to the segments of the abdomen. The last ventral ganglion, alone, is larger, for it furnishes, in addition, nervous filaments to the rectum, and to the excretory ducts of the genital organs.

Usually, the nerves arise in the ganglia by two or three principal roots. Some nerves, however, arise from the interganglionic cord. In those species where the ventral ganglia are entirely fused together, the nerves arise close together, but immediately diverge in different directions.

§ 329.

As to the Intimate Structure of the nervous system of the Insecta, both the nerves and the ganglia are always surrounded by a fibrous neurolemma, and, according to carefully-made researches, are never wanting in the two usual anatomical components. Between the extremely tenuous primitive fibres, are interposed, in the ganglia, very small globules. These last, nucleolated, usually contain also a finely-granular substance, colorless, though sometimes reddish or brownish.  

There are, with the Insecta, as with the Crustacea, two modes of the disposition of the fibres in the ganglia. The first, which form nervous, inferior cords, are disseminated in the ganglia; while the others, which belong to the superior nerves, simply pass through or over these ganglia. These two kinds of fibres give off, laterally, nervous filaments, which, uniting, form peripheric nerves of a mixed character. The superior cords correspond, probably, to the motor nerves, and the inferior to the sensitive nerves of the Vertebrata.

§ 330.

The Disposition of the nervous system in the various orders of Insecta presents the following differences:  

Among the Aptera, the ventral cord of the Pedicululidae is composed of three contiguous ganglia situated in the thorax. The prothoracic ganglion connects with the brain, and the metathoracic sends nerves to the abdomen.  

The nervous system of the Poduridae differs from this, in their three thoracic ganglia being separated, and their interganglionic longitudinal commissures being wide apart. More widely different still, is the ventral cord of the Lepismidai; it is composed of eleven ganglia connected by double longitudinal commissures.

With the Hemiptera, this system is limited to two thoracic ganglia, of which the anterior is the smaller. With Pentatoma, and Cicada, these two ganglia are not separated except by a constriction; while, with Nepa,

1 It was undoubtedly from their extreme delicateness that these ganglionic globules were overlooked by Trexianus (Beitr. zur Auffärr. d. Erorschng. u. Gesetz d. organischn. Lebens. I. Hft. 2, p. 62). They have been distinctly seen by Ehrenberg (Ueber Strukt. &c. p. 56, Taf. VI. fig. 8 (Gastropdes)), Pappebeim (Die specelle Gewebs- liche d. Gehirnorg. p. 51), Heimbautz (Be fabric. Syst. nat. &c. p. 21), Hennaner (Recherch. microscop. &c. p. 71, Pl. VI. fig. 81, 82 (Aeschna)) and Will (Muller's Arch. 1844, p. 81).

2 This difference of the nervous cords was first pointed out by Newport with the pupa and imago of Sphinx ligustri (Philos. Trans. 1834, part II. p. 333, Pl. XIII.-XVII. and Cyclopaed. loc. cit. p. 946). Hagen (Ernat. Zeit. 1844, p. 361) has since observed it with Aeschna grandis and Gryllo- lata vulgaris.

3 Various and special accounts of the general disposition of the nervous system of insects may be found in Cuvier, Lecons, &c., III. 1845, p. 334. Stearnsdorff, Bib. der Natur. p. 36, Taf. II. fig. 7.

4 Niclot, loc. cit. p. 44, Pl. IV. fig. 1 (Synn- thurae).

5 Trexianus, Verm. Sclirift. II. Hft. 1, p. 17, Taf. IV. fig. 3.

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they are connected by two long commissures. From the posterior of these ganglia pass off, in a ventral cord, two main trunks, approximated, which send off, in their course, lateral branches towards the periphery; with *Pentatoma*, these two main trunks are fused into one.(6)

With the Diptera, the ganglionic chain is always connected by simple commissures. The number of ganglia varies with the families, and, usually, is proportionate to the length of the segments of the body.(6) The ventral cord is most concentrated with the Hippobosciidae,(7) the Oestridae, and the Muscidae calypterae; it consists of only a single thoracic ganglion, from which pass off nerves in various directions. The Muscidae acalypterae, on the contrary, the Syrphidae(8) and the Conopidae, have, beside this thoracic ganglion, one or two ventral ganglia; while the Scoenopiniidae have five, and the Tabanidae, Stratiomyidae,(9) Therevidae, Lepididae, Asilidae, and Boubylidae, have six. Their number is still larger with the Empididae, Culicidae, and Tipulidae; — there being, in the first, three thoracic and five abdominal ganglia; and in the last two, three thoracic and six abdominal ganglia. The larvae of the Diptera usually have one more pair of ganglia than the adults. It is only in those species whose ventral cord is fused into a single mass, that the same concentration is observed with the larvae.(90)

The larvae of the Diptera have either a moniliform ventral cord, composed of ten approximated ganglia, or a chain of eleven of these masses, connected by long commissures, which are often double.(10)

With the Strepsiptera, alike in the three states of larva, pupa and imago, the ventral cord consists only of a large thoracic ganglion, from which pass off nerves in various directions.(92)

With the adult Lepidoptera, the ventral cord consists of seven ganglia, of which the first two are the largest and belong to the thorax. The connecting commissures are not double except between the thoracic ganglia; those of the others being more or less fused into a single cord. In the Catterpillars, the ventral cord consists of eleven nearly equal ganglia; the two commissures between the first three of these, are quite wide apart;

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5 Trechatinus, Beitr. zur Anat. o. Physiol. d. Insektenwerk. III. 1, Taf. II. fig. 24 (Cicada), and L. Dufour, Recherch. sur les Hemispheres, p. 259, Pl. XIX. fig. 801-803 (Pentatoma, Népa and Ctenidae).
7 L. Dufour, Ibid. III. 1845, p. 64, Pl. II. fig. 12.
9 Slammerdamm, Bib. d. Nat. p. 270, Taf. XII. fig. 7 (Stratiomyae).
10 I have found the ventral cord of the larva of Oestrus obtusus concentrated into a single large ganglion, situated at the extremity of the thorax. I think, therefore, that the description of the nervous system of the larva of Oestrus ousis given by J. L. Fiecher (Observ. de Oestrus avini atque bivina. Diss. Lips. 1787, p. 32, or in Werner, Verumnum intestin. exposit. contin. teresia. p. 25, Taf. III. fig. 4), and according to which, two long ganglionic cords, connected by transversal anastomoses, extend the whole length of the body,—is based on incorrect observations. In the larvated Piophiles and Eristali, several ventral ganglia fused together form a single abdominal cord; see Slammerdamm, Bib. der Nat. p. 279, Taf. XLII. fig. 5, and Burmeister, Handb. loc. cit. Taf. XVI. fig. 10.
11 The larvated Stratiomyae have an abdominal cord composed of ten contiguous ganglia (Slammerdamm, Bib. der Nat. p. 284, Taf. XLI. fig. 5). With those of Cetera, Chironomus, Simia, and other Tipulidae, the ten ganglia are wide apart, and connected by double longitudinal commissures.
12 In the apodal larvae and the larvace-like larvae of Nesos Rostii, I have found this nervous mass in the first segment of the body which corresponds to the cephalothorax.

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* § 330, note 5. For the nervous system of Belostoma, with all its details, see Leidy, History and Anatomy of the hemipterous Genus Belostoma, in the Jour. Acad. Nat. Sc. Philad. 1. 1847, p. 65, Pl. X. fig. 13. — Ro.
† § 330, note 11.] In the larva of Corethra plumicornis, Leydig found the ventral cord composed of eleven, instead of ten ganglia; see Anatomische und Histologisches üb. d. Larve von Corethra plumicornis, in Siebold und Kolliker's Zeitschr. III. 1852, p. 488. — Eo.
while those of the others are usually fused together.\(^{13}\) During the pupa-
state, a remarkable change takes place. The commissures between the first and second, and the third and fourth ganglia, are gradually shortened. The ganglia are thereby gradually approximated, and, in the end, are fused together, forming the two thoracic ganglia of the adult, which send off nerves to the legs, and to the muscles of the wings. At the same time, the fifth and sixth ganglia entirely disappear or are fused into one.\(^{14}\)

With the Hymenoptera, the ventral cord is composed of seven to eight ganglia connected by double commissures. The first of these, smaller than the second, is, like it, produced by the fusion of several ganglia; and both are situated in the thorax. Of the remaining five or six abdominal ganglia, the last two are closely approximated, or fused into one.\(^{15}\) Here, as with the Lepidoptera, the number of ganglia in the ventral cord of the larvae, is eleven, as has been specially shown in the false caterpillars of the Tenthredinidae.\(^{16}\)

With the Orthoptera, and Neuroptera, the nervous system is nearly always composed, in their various states, of three thoracic and six to seven abdominal ganglia connected by double commissures and forming a chain as long as the body.\(^{17}\)

With the Coleoptera, the number and disposition of the ventral ganglia present the widest variations of all. The longitudinal commissures, always double, are shortened or even wholly wanting at certain points. The ganglionic chain is, therefore, more or less abbreviated, and sometimes the ganglia are almost fused into a single mass. In this respect this system here presents two principal types, the limits between which, however, have

\(^{13}\) For the nervous system of the larva of *Vaea

nessa urticae* and *Bombus mori,* see the figures of *Schwemmerdarn,* loc. cit. p. 361, Taf. XXVIII. fig. 3, and Taf. XXXIV. fig. 7; also for that of the larva and imago of *Cassus liniperda,* the works of *Lycot. Tract.,* &c. p. 196, Pl. IX., and in the Mem. du Mus. loc. cit. p. 191, Pl. LI. (17). For that of *Gastropacha pini,* pupa and imago, see *Soekau,* Anat. physiol. Untersuch. p. 40. Taf. VII. fig. 28; but see especially the excellent description of that of the larva, pupa, and imago of *Sphincta introstris,* for which we must thank *Newport.* Philos. Trans. 1832, p. 383, Pl. XVII. XIII; also, 1834, p. 255, Pl. XIII-XVIII., and Cyclop. &c. loc. cit. p. 943, fig. 406, 414, 415.

\(^{14}\) This metamorphosis of the nervous system was first observed by *Herold* (Entwickelungsgesch. J. Schmettinger, loc. cit. Taf. II.) with *Pontia brasileae,* and has since been confirmed by *Newport* with *Sphinx hispida* and *Varena urticae*; see Philos. Trans. 1834, Pl. XVI. fig. 20-30., and Cyclop. loc. cit. p. 962, fig. 420-423.

\(^{15}\) See *Schwemmerdarn,* Bib. der Nat. p. 201, Taf. XXII. fig. 6 (*Apis mellifera*); *Tetetranus,* *Bischlic, V. Taf. I. (*Bombus muscorum,* and *Brattl and Ruthezolf,* Medizin. Zeit. 11. p. 205, Taf. XXV. fig. 31 (*Apis mellifera,*). For the disposition of the ventral chain of the Lepidoptera in general, see, moreover, *L. Dufour,* Recherches sur les Orph. &c. p. 281. Pl. II. fig. 7 (*Oedipoda,* and p. 561, Pl. XI. fig. 150 (*Libellula.* According to *L. Dufour,* there are seven ventral ganglia with *Libellula* and *Epitrita,* while there are only six with *Perla* and *Phryganor.* But *Pictet* (Re-
cherch. pour servir à l'Hist. et à l'art. des Phry-
ganides. Pl. II. fig. 33-36) and *Burmeister* (*Handb. &c. II. p. 955, 899) assign to these In-
sects, in both their larva and their perfect state, eight ventral ganglia. There are even nine of these ganglia with the *Epiphanera,* according to *Burmeister* (loc. cit. p. 763). In the very chub-
bed larvae of *Myrmicola* there are eight contiguous

ventral ganglia beside two thoracic ones (*Cur-
vier, Lecom, &c. III. p. 341.* *Loew* (German's Zeitsch. IV. p. 424) remarks that the proper Neuro-
ptera are distinguished by the separation of their last two abdominal ganglia, while, with all the Or-
thoptera, they are fused together.*

\[^{16}\] \[^{17}\]
not yet been definitely fixed.\(^{18}\) The first type consists of an absence of all the longitudinal commissures, as is the case with most of the Lamellicornes, the Curculionidae, and the Scolytidae. Here, the ventral cord is limited to three ganglia connected together; of these, the first corresponds to the prothoracic, and the second, the larger, to the second and third thoracic ganglia. This last is succeeded by an oblong, ganglionic mass, representing the concentrated abdominal portion of the cord, and from which arise the nerves of the muscles of the abdomen.\(^{19}\) In the second type, the abdominal portion of the cord occupies the entire length of the body. This is the case with the Cistelidae, Oedemeridæ and Cerambycidae, which have five ganglia in the abdomen.\(^{20}\) With the larvae of the Coleoptera, these two types are more clearly defined, there being no intermediate forms.\(^{21}\)

\[\text{§ 331.}\]

The Splanchnic nervous system consists, with the Insecta, in all their states of a single and a double nervous cord. Sometimes the first, sometimes the second of these is the more developed.

The single Stomach-gastric nerve arises from the anterior border of the cerebral hemispheres, by two short filaments, which, directly in front of the brain, meet in a ganglion (Ganglion frontale) lying upon the oesophagus. From this ganglion are given off several nervous filaments which go to the upper lip; while, from the opposite side, arises a simple nerve and composed of eight ganglia with the Eulateridæ, Ceriæidæ and Telephoridæ.


19 See Strens, Considér., loc. cit. p. 391, PI. IX. fig. 1 (Melolontha vulgaris), and Blanchard, loc. cit. An analogous concentration of the nervous system occurs in the families of Homoptera, Gyrinidae, Nidulinae, and Scaphydiidae, where the ventral portion forms a single oblong ganglion, while the three thoracic ganglia are connected by double longitudinal commissures. In most of the other families, the three thoracic ganglia are more or less separated, and the abdominal portion is modified in various ways. With the Endomychidae, Meloloba, and Chrysochidae, there are only four abdominal ganglia connected by very short double commissures; see Audouin, Ann. d. Sc. Nat. IX. 1829, p. 36, Pl. XII. fig. 16 (Lyttia); Brandt, Med. Zool. 11, p. 103, Taf. XVII. fig. 2, Taf. XIX. fig. 19 (Melol. and Lyttia); Newport, Cycloped. loc. cit. p. 993, fig. 408 (Timarchus) and Joly, Ann. d. Sc. Nat. XI. 1844, p. 24, Pl. XIV. fig. 16 (Colaspis). With the Dynastidae, and with Bytura, there are six abdominal ganglia, and the commissures are also very short; see Burmeister, Hamb. loc. cit. Taf. XVI. fig. 9 (Dytiscus). This figure, however, is not fully exact, if compared with that of Blanchard (loc. cit. p. 343, Pl. X. fig. 3). With the Staphylinidae, Silphidae, and Hydrophilidae, the abdominal portion, although composed of eight ganglia, is not prolonged much into the abdomen; it is longer and composed of six to seven ganglia with the Carabidae, Lamellodiscæ, and Pyrochroidæ; see L. Dufay, Ann. d. Sc. Nat. VIII. 1826, p. 27, Pl. XXI. fig. 2 (Carabus), and Ibid. XII. 1840, p. 352, Pl. VI. fig. 9 (Pyrochroa). It is even still longer and composed of eight ganglia with the Elateridæ, Ceriæidæ and Telephoridæ.

20 See Blanchard, loc. cit.

21 With those species of the Lamellicornes, and Curculionidae, whose ventral cord is very much concentrated, the eleven large component ganglia are, with the larva, united into one knotty mass, without any trace of commissures; see Swammerdam, loc. cit. p. 101, Taf. XXXVIII. fig. 1 (Oryctes); L. Dufay, Ann. d. Sc. Nat. XVIII. 1842, p. 290, Pl. IV. fig. 11 (Cannus); Burmeister, Nat. Gesch. des. Entomol. p. 13, fig. 13, 14; Blanchard, Ann. d. Sc. Nat. loc. cit. Pl. XIV. fig. 1 (Cannus). With the larva of the Melolobidæ, Pyrochroidæ, Lamiidæ, Chrysomelidæ, Tenebrionidæ, as well as of most of the other families of the Coleoptera, the ventral chain occupies nearly the entire length of the body, and is composed of eleven ganglia having double commissures; the thoracic ganglia exceed but little in size those of the abdomen; see Brandt, Med. Zool. 11, p. 106, Taf. XVII. fig. 20, Taf. XIX. fig. 31 (Meloe and Lyttia); L. Dufay, Ann. d. Sc. Nat. XIII. 1840, p. 327, PI. V. fig. 8 (Pyrochroa), and XVIII. 1842, p. 172, Pl. V. fig. 17 (Dorcus) Newport, Cycloped. loc. cit. p. 945, fig. 404 (Timarchus); Joly, Ann. d. Sc. Nat. XI. 1844, p. 24, Pl. IV. fig. 14 (Colaspis), and Blanchard, Bibl. Pl. XIV. fig. 7, Pl. X. fig. 5 (Chrysomela and Tenebrion). It is only with the larva of the Carabidæ, Silphidæ, Staphylinidæ and Diaperidæ, that the ventral cord, although composed of eight ganglia, does not extend into the last abdominal segments; while that of the larva of the Dytiscidæ, composed of seven ganglia, does not reach beyond the middle of the abdomen; see Burmeister, Trans. of the Entomol. Soc. Lond. 1, p. 230, PI. XXIV. fig. 9 (Calosoma); Blanchard, Ann. d. Sc. Nat. loc. cit. Pl. IX. fig. 3, 5, Pl. XI. fig. 4, Pl. X. fig. 2 (Silpha, Staphylinus, Diaperus, and Dytiscus).
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(Nereus recurvens) which passes over the oesophagus to the stomach, giving off branches right and left. Reaching the stomach, it divides, after having formed a ganglionic enlargement, into two principal branches.

The double Stoiano-gastric nerve consists of one, two, or three pairs of small ganglia, situated behind the brain, on each side of the oesophagus, and communicating with each other, with the posterior extremity of the brain, and with the Nereus recurvens, by delicate filaments. These filaments send fine threads to the oesophagus, and, at certain points, anastomose with the single nerves.\(^1\)

With the Hemiptera, a single Splanchnic nerve has been observed, and, for the double system, there has been seen, on each side of the oesophagus, two small ganglia, one behind the other.\(^2\)

With the Diptera, the splanchnic system appears to be present; at least, there has been observed on the Chyliferous stomach of the Hymenoptera, a pair of filaments belonging, probably, to the double system.\(^3\)

The Lepidoptera have a highly-developed Nereus recurvens, which often forms, with the carpellers, several small ganglia lying behind each other on each side of the brain, and connected together by a double nervous arch. The double system arises on each side of the oesophagus, from two ganglia, situated one behind the other, which, with the carpellers and pupae, are often approximated to a blending together, and which send off, beside the filaments anastomosing with the recurrent nerve, threads to the dorsal vessel.\(^4\) The Hymenoptera, Neuroptera, and Orthoptera, also, have the two kinds of splanchnic systems. The double trunks are highly developed with the Acrididae, and the Gryllotalpidae, and have two pairs of ganglia at their upper extremity, beside one or two on their course; while, with the Libellulidae, Blattidae, and especially the Phasmidae, the single nerve is the most developed.\(^5\)

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2 Meeckel (Beitr. zur vergl. Anat. I. p. 4) has observed the Nereus recurvens in the common Clenida, and Brandt (Bemerk. &c. p. 23, Taf. II. fig. 3, 3) has observed the same with Lygus, and at the same time the ganglia of the double system.


4 The recurrent nerve was first discovered in the silk-worm by Steamerammad (Bib. der Nat. p. 132, Taf. XXVIII. fig. 3, p. 125). Subsequently, Lepelet. (Traité, &c. p. 574, Pl. XII. fig. 1, XII. fig. 1, Pl. XV. fig. 14, Pl. XVIII. fig. 1) described with the larva of the Goat-moth, the double system and its relations with the dorsal vessel. Since then, the two systems have been observed in the larva, pupae, and imagines of various Lepidoptera; see Suckow (Anatom. physiol. Untersuch. 40, Taf. VII. fig. 33-38, pupa and imago of Cynipex nigripennis), who has described the double system and the cardiac nerve. See also, J. Muller (Nov. Act. Acad. Nat. Cur. loc. cit. p. 97 (the recurrent nerve of a larva of Sphinx), and Brandt (Ibis, loc. cit. p. 1164, Taf. VII. fig. 3, 4, and Bemerk. &c. p. 20), who has described the two systems with the imago and larva of Bombyx mori. The works of Newport (Philos. Trans. 1832, p. 353, Pl. XII. XIII., and 1834, p. 389, Pl. XII. XIV.) on the larva of Spinus, the four pairs of oesophagus, are very distinguished.

5 See Treviranus (Verna. Schrift. III. p. 59), who thinks he has observed the Nereus recurvens with Apis mellifica; Brandt, also (Medizin. Zool. 11. p. 283, Taf. XXV. fig. 32, and his Bemerk. &c. p. 223), has described the two systems in this species, and in the Bumble-bee (Apis terricola).

6 According to Burmeister (Handb. &c. I. p. 310, Taf. XVI. fig. 6 (ecylpus migratatorius), the recurrent nerve leaving the frontal ganglion, runs backwards and ends, after a short course, in a ganglion which connects by two filaments with the internal ganglia of the double system. These last send off several branches to the oesophagus, and connect, through two filaments, with the external ganglia of the same system. From these external ganglia arise two lateral trunks which run along the oesophagus and are distributed to the gizzard, forming a nervous plexus having four ganglia. See, also, for the same species, Brandt, in the Isis, 1831, p. 1104, Taf. VII. fig. 5. According to this last author (Bemerk. &c. p. 29, Taf. XI. fig. 7-9), the double system of Gryllotalpa is similarly disposed, only the nervous plexus of the gizzard arises from two posterior ganglia of the two trunks. See, also, for that of Gryllotalpa, L. Dufour, Rec. sur les Orthopt. &c. p. 255, Taf. III. fig. 22. With Phasiana ferula, the four anterior ganglia of the single system are small, but, for compensation, the double system is very com-
The Coleoptera have, in both their larval and their perfect states, a feebly-developed double nervous system arising from two pairs of ganglia, and a highly-developed *Nervus recurrents* which, with a few species, forms, directly behind the *Ganglion frontale*, a second ganglion. It runs along the oesophagus, and usually forms, posteriorly, still another ganglion, and then divides dichotomously.

A great number of the Insecta have, in all their states, another system of nerves, called Respiratory nerves, which, in view of their functions, ought very properly to be classed among the mixed nerves, for they contain not only motor, but also vegetative fibres. This system arises by several single roots from the longitudinal commissures of the ventral cord. Each of these roots divides into two *Nervi transversi* which deviate from each other at right angles, and anastomose with the ganglia of the ventral chain and with its peripheral nerves, receiving at the same time organic fibres from the ganglia of the double splanchnic system. These respiratory nerves are distributed to the large tracheal trunks, and especially to the muscles of the stigmata. The respiratory movements of Insecta cannot, therefore, be regarded as properly of a voluntary nature..

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**CHAPTER IV.**

**ORGANS OF SENSE.**

§ 332.

The sense of Touch appears to be seated, with Insecta, in very different parts of the body. It is chiefly located in the palpi of the mouth, which, for this purpose, are usually terminated by a soft surface. The antennae, also, serve as tactile organs, but in a very various manner, according to their forms, the degree of their development, and the habits of

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*Although Lyneac (Traité, &c., p. 98, 201, Pl. IV. fig. 5, Pl. IX. fig. 1) had already described this respiratory system with the larva of the goat-moth, under the name of *brides epipinéres*, it is Newport who has recently called the attention of anatomists to this subject, by furnishing, with admirable details, the disposition of this respiratory plexus, in the larva, pupa and Image of *Sphinx ligustri* (Philos. Trans. 1832, Pl. XII. fig. 4, 1834, Pl. XIII. &c., and 1836, Pl. XXXVI., also Cycloped. loc. cit. p. 497, fig. 496). See, also, Müller’s ideas (Archiv, 1835, p. 82) on the nature of this nervous system. With various Coleoptera and Orthoptera, with *Locusta*, *Oryctes*, and *Corax*, the single roots arise, according to Newport, from small ganglia, at the points where are given off the *Nervi transversi*.  

1 For the sense of the Insecta in general, besides the works of *Spence and Kirby, Burmeister and Locardaire*, see Schéffer’s *Versuch einer Naturgesch. d. Sinneswerke*, bei d. Insekten u. Wirrnern, 1798, a work in which are related the opinions of the older naturalists on this subject.  

2 The tactile sense of the palpi is of great service to Insecta when they eat; for these organs are used not only to feel the food but also to retain, and convey it between the jaws.
the species. These organs receive, each, directly from the superior cerebral mass, a nerve; these nerves perceive the slightest disturbances occurring in the antennal teguments, which are solid and often provided with hairs and bristles. With those Insecta with which these organs are very long, filiform, and movable in various directions, they serve, like the vibrissae of many mammals, to announce the presence of external bodies. With very many other Insecta, they are very movable, and are distinctly used as tactile organs, like the fingers of the human hand. It is also by means of these organs, that insects perceive the various conditions of the atmosphere, especially the temperature, and thereby regulate their movements and actions.

With those Insecta whereof the parts of the mouth are changed into organs of suction, it is quite evident that the extremity of the snout or proboscis is the seat of a very delicate sense of touch. Also with those female insects having an ovipositor, which is used to deposit their eggs in holes of various depth, the apex of this organ must be endowed with the same power. Finally, this sense must be ascribed to the extremities of the legs of many Insecta, which, in either their larval or in their perfect state, use these organs for the performance of labors of a special nature. With the Poduridae, there is, upon the ventral surface of the first abdominal segment, a singular organ which is soft, protractile, bifurcated or bi-lobed, and probably of a tactile nature.

§ 333.

Undoubtedly the sense of taste, with Insecta, is seated in the tongue, when this organ is present. The tongue, of a soft consistence, is particularly developed with the Carabidae, Loeustidae, Acrisidae, Libellulidae, and Vespidae, which are all mandibulated; and with the Apidae, and Muscidae, which lick up their food. With the suctorial Insecta, the tongue is either wanting, or changed into a horny bristle; — a transformation met with, also, in certain species having masticatory organs.

§ 334.

The organs of Olfaction with Insecta, have not yet been satisfactorily determined, although most of these animals by their aid, can perceive in a most wonderful manner, the food proper either for themselves or their young. The various hypotheses upon this subject are unsatisfactory, and especially those by which this sense is located in the hard and dry parts of the body, which are quite unfit to recognize odoriferous substances.

3 This may be especially observed with the Hymenoptera.

4 As such I recollect only the Ateuchidae and Rhyncholecia among the Coleoptera, the Esservial Hymenoptera, and the larvae of the Phyrgaenidae among the Neuroptera.

5 With Stenopteryx, these organs consist of two long protractile cylinders; see Deger, Abhann. &c. VII. p. 20, Taf. III. fig. 10, and Nicolet, Recherch. &c. p. 42, Pl. III. fig. 5, 13-22. I am not determined whether or not should be placed in the same category the soft protractile organs, often of a beautiful red or orange color, possessed by Machaeras on the lateral portions of the body, by Stenus at the extremity of the abdomen, and by the larve of various Lepidoptera (Papilio machaon and podalirius, Harpyia vindex, &c.) on the neck or head.

1 According to Rosenthal (Reil's Arch. X. p. 471, note 5.) See upon the protractile, tentacular organs of the larve of the Papiliones, Karsten (Muller's Arch. 1848, p. 575). I have carefully and microscopically examined these organs with Papilio asterias; I regard them as odoriferous and defensive, rather than tactile organs. — En.
§ 335.

There is the same uncertainty concerning the organs of Audition. Experience having long shown that most Insecta perceive sounds, this sense has been located sometimes in this, and sometimes in that organ. But in those opinions, it often seems to have been forgotten or unthought of, that there can be no auditory organ, without a special auditory nerve which connects directly with an acoustic apparatus capable of receiving, conducting, and concentrating the sonorous undulations. 1)

Certain Orthoptera are the only Insecta with which there has been discovered, in these later times, a single organ having the conditions essential to an auditory apparatus. This organ consists, with the Acrididae, of two fossae or conchs, surrounded by a projecting horny ring, and at the base of which is stretched a membrane resembling a Tympanum. On the internal surface of this membrane, are two horny processes to which is attached an extremely delicate vesicle filled with a transparent fluid and representing a membranous labyrinth. This vesicle is in connection with an auditory nerve which arises from the third thoracic ganglion, forms a ganglia upon the tympanum, and terminates in the immediate neighborhood of the labyrinth by a collection of cuneiform, staff-like bodies with very finely-pointed extremities (primitive nerve-fibres?), which are surrounded by loosely-aggregated, ganglionic globules. 2)

The Locustidae and Acetabidae have a similar organ, situated in the

1) Burmeister (Handb. d. Zool. 1839, I, p. 312). J. Müller (Zur vergleich. Physiol. d. Gesichtssinn, p. 439, and Nov. Act. Nat. Curr. XIV. Tab. IX.) was the first who fortunately conceived that with Gryllus hieroglyphus, this was an auditory organ. He gave, however, this interpretation only as hypothetical; but I have placed it beyond doubt by careful researches made on Gryllus, Oecanthus, Poecilus, Caloptenus and Trusalis (Wiegmann's Arch. 1844, 1, p. 56, Tab. I. fig. 1-7).

2) See also Burmeister (Zett. für Zool., Zoöt., und Paläontol. von D'Allon and Burmeister, No. 6, p. 49, Tab. I. fig. 29-33), who likewise advocates the auditory function of the antennae. But Burmeister and Erichson differ somewhat in their statements upon the intimate auditory structure of these organs, and, therefore, as to the exact mode by which audition occurs.—Eo.
fore-legs directly below the coxo-tibial articulation. With a part of the Locustidae, there is, on each side at this point, a fossa; while with another portion of this family, there are, at this same place, two more or less spacious cavities (Auditive capsules) provided with orifices opening forwards. These fossae and these cavities have each on their internal surface, a long-oval tympanum. The principal trachean trunk of the leg passes between the two tympanums, and dilates, at this point, into a vesicle whose upper extremity is in connection with a ganglion of the auditory nerve. This last arises from the first thoracic ganglion, and accompanies the principal nerve of the leg. From this ganglion in question passes off a band of nervous substance which stretches along the slightly excavated anterior side of the trachean vesicle. Upon this band is situated a row of transparent vesicles containing the same kind of cuneiform, staff-like bodies, mentioned as occurring with the Acrididae. The two large trachean trunks of the fore-legs open by two wide, infundibuliform orifices on the posterior border of the prothorax, so that here, as with the Acrididae, a part of this trachean apparatus may be compared to a Tuba Eustachi. With the Achetidae, there is on the external side of the tibia of the fore-legs, an orifice closed by a white, silvery membrane (Tympanum), behind which is an auditory organ like that just described.

§ 336.

The organs of Vision consist of simple, or of compound eyes. The first occur chiefly with the larvae of holometabolous Insecta; and the second with Insecta in their perfect state. There are, however, many species which have both kinds of eyes in their imago state. These organs are wanting with only a few adult Insecta, but are wholly absent with many larvae and pupae of the holometabolous species.

I. The Simple eyes (Ocelli, Stemmata) are composed of a convex, spheroidal, or elliptical cornea, behind which is a spherical or cylindrical lens, lodged in a kind of calyx formed by an expansion of the optic nerve, and which is surrounded by a variously colored pigment-layer, as by a Chorioidea. These stemmata are sometimes so closely situated

1 For the eyes of the Insecta, see Marcel de Serres, Mem. sur les yeux camp. et les yeux lisses d. Insect. Trans. Acad. Sci. Nat. XVII. 4, p. 424 (in extract), and his Memoir in Meckel's Arch. 1829, p. 58.
2 The eyes are wanting in many species of Psittium which live under the bark of trees (Erichson, Naturgesch. d. Insek. Deutschl. III. p. 52); with Anopalthamus, which live in caverns (Sturm, Deutschl. Fauna Abt. V. Bd. XV.), and with Cleiogaster, which live in ant-seats.
3 As such may be cited the larvae of Hymenoptera, excepting however, those of the Tenthredinidae; those of the Diptera, which live in decomposing animal and vegetable substances; those of the Blattaria, Histeridae, Lepidóptera, Neuroptera, and in general the apodal larvae of Coleoptera; finally, the parasitic larvae of the Strepsiptera, whose females are also blind in the imago state.
4 For the simple eyes of Dytiscus, see Müller, in Meckel's Arch. loc. cit. p. 50, Taf. III. fig. 1, 2; for those of Cicada, Vespa, Bombus, and Libell.
on the brain that their optic nerves consist only of small papillae on this last; but, when further removed from the brain and grouped together, the optic nerves arise by a common trunk which divides into as many branches as there are eyes.

The number and disposition of the stemmata vary very much in the different orders. When they alone constitute the visual organs, they are always situated on the lateral parts of the head,—where they may be disposed either, as one on each side, or as several irregularly grouped together (Ocelli gregati), or regularly arranged in rows (Ocelli seriati). There is only one simple eye on each side with the Pediculidae, Nirmidae, Coccidae, the larvae of the Phryganidae and Tenthredinidae, and the aquatic ones of very many Diptera. These organs are in groups of four to eight with the Poduridae, with the larvae of Lepidoptera, the hexaped larvae of the Strepsiptera, the larvae of the Hemerobidae, Mycetinidae, Raphididae, and with the hexaped ones of the Coleoptera. The winged males of the Strepsiptera have the largest number of stemmata aggregated in groups; they here form two lateral, globe-like projections, and constitute the transitional form to the faceted eyes, for there are fifty to seventy on each side, separated from each other only by hairs. Very many Insecta with two, faceted eyes, have, also, on their front, three stemmata disposed in a triangle.

2. The Compound eyes, or those whereof the cornea is faceted, are composed of simple eyes so thickly set together that their more or less thick, slightly convex, quadrangular, or hexagonal cornea are contiguous.

The size of these facets is not uniform even in the same eye, for sometimes those above, or those in the centre, are the larger. Behind each cornea is situated, in place of a lens, a transparent pyramid the apex of which is directed inwards and received into a kind of transparent calyx corresponding to a Corpus vitreum. This last is surrounded by another calyx formed by the expansion of a nervous filament arising from the

lata, see Trevisanis, Beitr. &c. p. 84, Taf. II. fig. 25-35.
5. Schwannius, Apis, Vespa; see Trevisanis, Eigodog, V. fig. II. and his Beitr. &c. Taf. II. fig. 29; and Brandst. and Raitzeg. Medicin. Zoö. II. Taf. XXV. fig. 31-32.
6. With many of the larvae of the Lepidoptera and the Coleoptera, the optic nerves arise by two more or less long roots; see Lyconet, Trait. &c. p. 531, Pl. XVIII. fig. 1, No. 1, and fig. 6 (larva of the goat-moth); Suckow, Anat. physiol. Untersuch. p. 41, Taf. III. fig. 34 (pine caterpillar), and Hormester, Trans. Entom. Soc. I. p. 229, Pl. XXIII. fig. 7 (larva of a Calosoma). The three stemmata of Cicada receive their nerves from a common trunk arising from the middle of the brain. see Trevisanis, Beitr. Taf. II. fig. 24, and L. Dujou, Recherch. sur les Hémipéres, &c., Pl. XIV. fig. 293.
7. See Niclot, Recherch. sur les Poduridae, loc. cit. p. 28, Pl. II. III.
8. Such are the carnivorous larvae of the Carabidae, Staphylinidae, Byrrhidae, Bembididae, Silphidae, &c., and the herbivorous larvae of the Chrysomelidae. Those of Cicindela have only two large stemmata on each side of the head, and those of Lycus, Melas, Lampyris and Cantharis, have only one.
10. There are three frontal stemmata with many of the Orthoptera (Mantidae, Acrididae, Libellulae, Perlidae, Pscoidea, Ephemeridae and some Phasmidae); with some Neuroptera (Hemerobius, Panorpa, Phryganea), and Hymenoptera (Pentatom., Coreus, Hertog, Cicada). This is the case also with many Diptera, such as the Muscidae, Syrphidae, Stomoxidae, Bombylidæ, Anthribidae, Osiridae, Asilidae, Empidace, &c.; they are wounding with Tabanus, Haematopota, Conopus, Hippobosca, Melophagius, and many of the Tiphinae. With the Hymenoptera, they are constantly present except with the neater ants and with the females of Mutilla and Myrmodes; there are only two of these eyes with most of Tyria; Scaphis, Mycetobia and Lauxani, of the Diptera; Sesia, Empo- prea, Pyralis and a great number of the Noctu-idea, of the Lepidoptera; Gryllotalpa, Idiota and Termes, of the Orthoptera; and Omalus and Anthophagus, of the Coleoptera.
12. These differences in the size of the facets had been observed by Marcel de Sèvres (loc. cit. p. 48) with Libellula. They exist also in the eyes of Lauris flavus, gibbosa, atrata, Tabanus rusticus, and some other Diptera; see Ashton, Trans. Entom. Soc. II. p. 255, Pl. XXI.
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ganglion on the extremity of the optic nerve, a short distance from the brain. Each lens-like pyramid with its vitreous body and nervous filament is enveloped by a Chorioidea usually of a brown color, which forms, behind the cornea, a kind of pupil, but to which are due, by no means, the beautiful colors so often observed in the eyes of these animals.

The size and form of the compound eyes, as also the number of their facets, are very varied. The larvae and pupae of the hemimetabolic Insecta have, usually, a less number of facets and consequently smaller eyes, than the perfect forms. With the Libellulidae, and Diptera, the eyes are very large; while with the Formicidae, they are perhaps the smallest of all. With many Diptera, and some Hymenoptera, those of the males are much larger than those of the females, and are often contiguous in front or above. With some Hymenoptera, and Diptera, they are pilose, — the hairs being inserted in the angles of the facets.

The compound eyes are usually spherical or oblong; and, with many Cerambycidae, and with the Vespidae, they are deeply emarginate in front, or on their internal border. With Diopsis, they have a very singular appearance, being supported on two very long, rigid, frontal processes, and their direction cannot, as with other Insecta, be changed without a turning of the head.

CHAPTER V.

DIGESTIVE APPARATUS.

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The Insecta very often use their labial and maxillary palpi to seize and to convey food to the mouth, and even to introduce it wholly within this last. With many species, the fore-legs are used to seize and retain the food, and the first pair is sometimes changed for this purpose even into rapacious organs. With the larvae and pupae of the Libellulidae, there

13 According to Müller (Arch. 1833, p. 613), these retinæ are formed only by a prolongation of the neurilamina, while the proper nervous substance does not extend beyond the extremity of the vitreous body; but Wilt denies this (Müller's Arch. 1843, p. 349).
14 Each of these pupils, according to Wilt (Müller's Arch. 1843, p. 350), is moved by thirty to thirty-five delicate fibres which arise on the four transparent cylinders surrounding the pyramidal lenses; but Brants (Tijdschr. voor natuurlijke geschied. en physiologie, 1844, II.) regards them as traheothan branches and not contractile fibres.
15 The beautiful emerald color of the eyes of many Libellulidae, Tabanidae, Hemerobiidae, &c., is due to the cornea; for the chorioidea are of the same dead color as those of other Insecta.
16 There are sometimes several thousands of these facets in the eyes of large size; see Müller, Zur vergleich. Physiol. J. Geschicht. &c., p. 349; and Wilt, Beitr. &c. p. 10.
17 The largest eyes are observed with the Hemo-
phæa, where they cover nearly the whole head; see Erichson, Entomographien. Hft. I. p.135, Taf. I.
18 Among the Hymenoptera, the genera Astata, Larra, Tachytes, Aphis; and among the Diptera, the Muscidae, Syrphidae, Leptidae, Tabanidae, Bratiænyctæ, and many other families.
19 With Aphis, Tabanus, Anthomyia, Eristalis, Volucella, and other Diptera.
20 See Linne, Acanthostiga academicae, VIII. Tab. VI. and Dallman, in Fœcisty's Archivs J. Insect. Hft. 1, Taf. VI. or 1820, p. 501, Taf. V.
21 The Insecta scarcely move their head when they look in different directions. This renders very singular the extended mobility of the head with Mantis religiosa, which, in watching for its prey, looks on all sides.
22 For example, with Syrits, Nacoris, Nepa, Ramatra, Hemerodromia, Mantis, Mantispæ, &c.
is, attached to the under lip, a peculiar prehensile organ which covers, like a mask, the masticatory organs, and, by means of a double articulation, can be let down and then returned with the utmost quickness. During this manoeuvre, the prey is seized by two acute hooks inserted on the anterior border of this lip, and carried to the mouth.\(^{(2)}\)

The parts of the mouth of the Insects may be divided into Masticatory and Suctorial organs, between which, however, there are many intermediate forms. The second are, properly speaking, modifications of the first, and for this reason, the last should be described first; the special details of these organs, however, belong to the domain of Zoology.

These masticatory organs\(^{(3)}\) consist of a pair of Mandibles and a pair of Maxillae, which move laterally and are more or less covered by an upper (\textit{Labrum}), and an under (\textit{Labium}) lip. The upper jaws (Maxill\textit{ae}) exceed in hardness all the other parts of the masticatory apparatus, and consist of two simple, horny organs, often denticulated at their extremity. The under jaws (\textit{Maxillae}) are, usually, softer, and composed of several pieces, — of which the most essential are: \textit{Palpi maxillares}, composed of from one to six articles, and directed outwards; and the stipule, usually denticulated or ciliated, and divided into a \textit{Lobus externus} and \textit{internus}. The under lip, which supports two \textit{Palpi labiales} composed of from one to four articles, may thus be considered as another pair of maxillae the lateral halves of which are more or less fused together on the median line.\(^{(4)}\) Such are the oral organs with the Coleoptera, the Neuroptera, and the Orthoptera. It is interesting to remark that the Orthoptera, in the widest acception of the term, have in common, this character, that their under lip is divided by a deep fissure into lateral halves, while that of the Neuroptera and Coleoptera consists of a single piece.\(^{(5)}\)

At the base of the under lip is attached the tongue, which, either fleshy or horny, is single or cleft. Often it is completely abortive, but in other cases, on the contrary, it is very long and changed into a suctorial organ. This last form is most prominent with the Hymenoptera, where the two jaws have, at the same time, ceased to be masticatory organs, and form a sheath enveloping the tongue and labial palpi.\(^{(6)}\)

The oral parts are changed into suctorial organs with the Diptera, Hemiptera, and Lepidoptera. The first have a \textit{Proboscis}, formed by the under lip transformed into a suctorial tube (\textit{Theca}) which is often geniculate. At its base are from four to six bristles which may be regarded, some as maxillae and mandibles, and others as representing the tongue.\(^{(7)}\) With


\(^{4}\) This opinion, before advanced by Oken, Savigny, and Leach, has been sustained with very many details by Brunel (Anno. d. Sc. Nat. II. 1814, p. 324).

\(^{5}\) On account of these modifications of the under lip, to which Erichson (Entomograph. II. 1. p. 5, and in German's Zeit. I. p. 150, Taf. II.) has especially called our attention, we can distinguish, in their perfect state, the hemimetabolous Neuroptera. This justifies the separation we have made of the first whose pupae take food and are active, from the second whose pupae are inactive and do not eat. We have placed these last among the Orthoptera, because, like them, they have in all their states a bispid under lip. The differences between the under lip of the Orthoptera and that of the Neuroptera are well shown in Savigny's excellent figures of the maxillary organs of these insects (Descr. d. l'Egypte, Orthopteres, Pl. I.-VII. und Neuropteres, Pl. I.-XIII.

\(^{6}\) See Skimmermanna, Bibl. der Nat. Taf. 11., fig. 5; Tretraux, Versch. Schriffl. II. HR. 2, p. 112, Taf. XII.-XIV.; Brandt and Katschburg, Wolsch. Zeits. II. Taf. XXV., fig. 8-16; Newport, Cyclop. loc. cit. p. 897, fig. 375, 376; but especially Savigny, Descrip. d. l'Egypte, Hymenopteres, Pl. I.-XX.

\(^{7}\) See Savigny, Mem. sur les anim. sans vert.
the Hemiptera, the sectorial apparatus is lengthened into a Rostrum, by the under lip being changed into two quadri-articulate grooves united so as to form a tube, and enclosing the scitiform mandibles and maxillae. With the Lepidoptera, the changes are still greater; for the mandibles are only very small appendages, while the maxillae are transformed, each, into a semi-canal which can be rolled up spirally, and when united form an organ of suction (Lingua spiralis). At the base of this last are two very short maxillary palpi, bi- or tri-articulate, while the two tri-articulate and very hairy labial palpi consist of two pretty large appendages between which the sectorial tube retreats when rolled up.

The buccal organs begin to atrophy with the Aptera. The four palpi present with the Lepismiacea, are already wanting with the Poduridæ; and with the Nimmidae, they, as well as the maxillae, are very small, while the mandibles are quite large.

With the Pediculidae, there are still wider modifications; for here there is a protractile sectorial tube composed of four stiff bristles (rudimentary jaws) which are enclosed in a soft and equally protractile sheath (under lip). With the Larvae of Insecta, the buccal organs are most usually masticatory; for, not only the larvae of the Coleoptera, the Orthoptera, and many of the Neuroptera and Hymenoptera, have the same organs of this kind (masticatory) as the perfect insects, but also the larvae of the sectorial Lepidoptera, and those with a distinct head of certain Diptera with which, however, the maxillae and palpi are very frequently wanting. But with the acetalphalous larvae of Diptera, those of the Strepsiptera, as also with the parasitic ones of some Hymenoptera, the mouth is formed rather for sucking than for masticating the food; for, on the inner side of the soft tymid lips, either the horny organs are wholly wanting, or the mouth is armed with two parallel hooks, which are used partly to grapple and partly to puncture the bodies these animals attack.

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the mouth of the Diptera presents appendages wholly comparable to those of the other Insecta, except that these appendages are modified in a special manner. — Ec.
The mouth of the larvae of the Myrmeleontidae, Hemerobidae, and Dytiscidae, is of a very peculiar construction. There is no oral orifice, properly speaking, and the maxillae and mandibles are wholly unfit for mastication, the latter being changed into two curved hooks, hollow and with a narrow fissure at their extremity. These larvae bury these hooks in the insects they have seized, and through the cavity of these organs, which communicates at its base with the oesophagus, suck the blood.\(^{(18)}\)

A considerable number of the Insecta take no food during their perfect state, the object of their existence being only to accomplish the act of reproduction. Their jaws are often very rudimentary and are fit neither for sucking nor for masticating.\(^{(19)}\) In some cases, indeed, not only are these organs wanting, but the oral orifice is closed as with all inactive pupae.\(^{(20)}\)

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The Digestive Canal of Insecta and their larvæ, is more or less long, sometimes extending from the mouth directly to the anus upon the median line; sometimes forming in the abdomen loops and convolutions. It is retained in place not by a mesentery, but by numerous fine tracheæ, which envelop its entire extent. It is always wholly invested by a homogeneous peritoneal envelope under which lies a muscular tunic, composed of longitudinal and circular fibres, which are especially developed about the mouth and anus. Internally, it is lined throughout by an epithelium which is extremely thin at the middle portion of this canal, but very solid and composed of chitine at its two extremities. In the middle portion just mentioned, there is a layer of aggregated cells, evidently of a glandular nature, between the epithelium and the muscular tunic.

The different parts of this canal in the Insecta may be properly distinguished in the following manner. The first portion is the \textit{Oesophagus}, muscular, occupying the three thoracic segments and often dilated at its posterior part into a crop (\textit{Inglutivies}) and muscular gizzard (\textit{Proventriculus}). Sometimes there is appended to the oesophagus a sucking stomach consisting of a more or less pedunculated, thin-walled vesicle, which is multiplicated on itself when empty.

The second portion consists of a \textit{stomach} (\textit{Ventriculus}), in which the chyle is formed, and which is continuous at the point of insertion of the Malpighian vessels, with the third portion of the digestive canal. This third portion commences by a small and usually short \textit{Ileum}, which is followed by a \textit{Colon}, larger and of variable length. This last often has a \textit{Caecum} at its anterior extremity and terminates posteriorly in a short muscular \textit{Rectum}.\(^{(1)}\)

\(^{(18)}\) See \textit{Roesel}, Insektenbeobacht. III. Taf. XVII. XVIII. (Myrmeleon); II. Insect. aquat. class. I. Taf. I-II. (Dytiscus); \textit{Ratzburg}, Forstinsekt. III. Taf. XVI. (Hemerobius). With the larva of \textit{Dytiscus}, the body of the maxillæ is wholly abortive, but always provided with palpæ. With those of \textit{Hemerobius}, the maxillæ are small, deficient in palpæ, and play in a groove on the concave side of the mandibles; finally, with those of \textit{Myrmeleon}, these organs are wholly enclosed in the cavity of the mandibles.

\(^{(19)}\) The maxillæ are rudimentary and very soft with the Ephemeridae, and Phryganidae, in the last stages of their development. The very short proboscis of many Bombylidae and Heliopidae, appears equally unfit to receive food. Finally, the two small, intercrucial maxillæ of the males of the \textit{Sirensiptera}, are wholly inadequate for the functions of masticatory organs.

\(^{(20)}\) Movable oral organs and an oral orifice are wanting with many Oestridae, and Hemipteridae, as well as with the male Cicadas.

\(^{(1)}\) The functions of these different portions of the digestive canal do not always correspond to those of those parts having the same names with Vertebrata. \textit{Burmeister} (Ueber Natargesch., d. Calabura p. 9) is certainly correct in saying that the stomach is the chylöpoietic part, thus combining the func-
With nearly all Insecta in their perfect state, this colon or large intestine contains from four to six organs of a peculiar structure and doubtful function. These consist of transparent protuberances, disposed in successive pairs, or forming a transverse series. They are round, ovoid, or oblong, their base being sometimes surrounded by a horny ring, and they are traversed by numerous tuft-like tracheae. The Lepidoptera, especially, are remarkable for their numerous organs of this kind. It is singular that they are wanting in all insects during their larval and pupa states.

The Anus of Insecta, in all their states, is invariably situated on the last segment of the body. With the quiescent and non-feeding pupae, both the anus and the mouth are wanting, but with the larvae of only the Strepsiptera, the Apidae, and the Vespidae, are both ileum and colon wanting at the same time.

The form and disposition of the different parts of the digestive canal vary infinitely, according to the habits of life and the states of development of the Insecta in which they are observed. On this account it is very difficult to make any general statement of the various structural relations. But that condition may be taken as the fundamental type which belongs to those perfect insects whose life is pretty long and which have masticatory organs. Such, therefore, will receive our first consideration.

With the Coleoptera, the oesophagus is nearly always terminated by a

tions of the stomach and small intestines of the Mammalia. The crop and gizzard correspond to parts of the same names with birds. The ileum, which is usually regarded as analogous to the small intestine of the Vertebrata, probably plays a very subordinate part in the act of digestion. Burmeister thinks that it serves only to conduct the chyme or chyle, but with certain species where it is very long, it is probably the seat of a second digestion. The caecum often serves to receive the secretory product of the Malpighian vessels, and therefore belongs rather to the urinary than to the digestive apparatus (see § 346).

It is hardly comprehensible how organs so common with the Insecta, should, as yet, be so little known.

Swammerdam, however, observed them with Apis mellifica (Bib. der Nat. Taf. XVIII. fig. 1), and stuck (Hesser's Zeitsch. III. p. 21, Taf. VI. fig. 121, 125) has mentioned them with Vespa crabro, and Apis mellifica, under the name of callus swellings. Brandt and Ratzeburg, Mediz. Zeit. 1839, Taf. XXV. fig. 2 (Apis mellifica), as well as Burmeister (Hdb. Sc. 1. p. 143) speak of them very slightly. L. Dufour (Recherches sur les Orthopt. Sc. p. 396, 427) has figured them with various Orthoptera, Neuroptera and Hymenoptera under the name of Boutons charnus; finally, Newport (Cyclopaed. Sc. p. 970, fig. 434, Carabus monilis) has designated them as glandular protuberances. All the figures above cited give the external form of these organs but not their internal structure. They are especially apparent and four in number with the Muscidæ; see Rambour, Abhandl. ub. d. Verdauungswerkz. &c. Taf. XIX. fig. 2, M. M.; and Suckow, loc. cit. Taf. IX. fig. 153. The four with Meliponæus are very singular and different from those of the other papilionidæus. Dipitera, in that their external surface is covered with small solid scales; see L. Dufour, Ann. d. Sc. Nat. III. 1845, p. 71, Pl. II. fig. 13–15.

I have counted, with the Zygænaæ, thirty of these swellings, and nearly a hundred with the Papilionæ, Noctuidæ and geometridæ. Hapiæna, Tinea, and Adeia, have, by exception, only six. Treuaraigns (Vern. Schrif. II. p. 136, Taf. XII. fig. 4), and Lyonet (Lém. du Mus. Sc. XX. p. 154, Pl. XVII. fig. 6) have taken these organs for glands with Papilio.

The digestive canal is probably organized in a similar manner with the larvae of the Hymenoptera and the Diptera, which are parasitic in the bodies of other insects.


The digestive organs of the Coleoptera have been especially studied by L. Dufour (Ann. d. Sc. Nat. II. 1824, and I. 1834). See, moreover,
crop-like dilatation,\(^{[6]}\) which, with the Cicindelidae, Carabidae, Dytiscidae, and Gyrinidae, is followed by an ovoid gizzard. This last is longitudinally plicated internally, and these folds are usually armed on their borders with cilia or horny hooks. The intestinal stomach is of median length with the carnivorous Coleoptera, but very long and more or less flexuous with those which are herbivorous.\(^{[8]}\) Nearly always, its whole external surface is numerously constricted, and covered with small caeca.\(^{[9]}\) The ileum and colon are, usually, rather short.\(^{[10]}\)

Among the Orthoptera, the families Forficulidae, Termitidae, Blattidae, Acetidae, Locustidae, Acrididae, and Mantidae, are distinguished for their large crop,\(^{[11]}\) which, with Grilloptera, is completely constricted on the oesophagus. The gizzard is of variable length, and covered internally, with rows of horny denticulated plates.\(^{[12]}\) The stomach is tubular, of equal calibre, median length, and rarely makes a half or an entire turn.\(^{[13]}\) In most of the families just mentioned, its upper extremity has two, six, or eight caeca,\(^{[14]}\) and its posterior part is continuous into an often somewhat flexuous ileum upon which succeeds a short colon. With the Peridiae, the gizzard is wanting, but the upper extremity of the stomach has from four to eight caeca, pointing forwards.\(^{[15]}\) With the Phasmidae, and the Libellulidae, the oesophagus is long and large, and protrudes somewhat into the straight, oblong, constricted stomach, which is without caeca and is succeeded by a very short ileum and colon.\(^{[16]}\) The digestive tube of the Ephemeridae, which, in their perfect state, take no food, is feebly developed. Its walls are very thin throughout, and the oesophagus is directly continuous with the stomach which is a bladder-like dilatation and succeeded by a short, straight intestine.\(^{[17]}\)

Ramdohr, Magaz. d. naturf. Freunde zu Berlin, 1867, p. 207, Taf. IV. (Carabus); Brandt, Mediz. Koll. II. Taf. XVII. XIX. (Meloc and Lytta); Strous, Consider. &c. Pl. V. (Melolontha).\(^{[7]}\)

With Oedemera, this crop is constricted from the stomach; see L. Dufour, loc. cit. III. Pl. XXX. fig. 7, 8.

The stomach is of the greatest length with the Melolonthidae and Hydrophilidae; see Strous, loc. cit. Pl. V., and Suckow, loc. cit. II. Taf. III. IV.

This constricted stomach is especially observed with the herbivorous Coleoptera, as, with Meloe, Lytta, and Cantharis; but is wholly wanting with Lyceu, Telephorus, Malachius, and Castela. With the Elateridae, the stomach is smooth, but, at its upper extremity there are two caecal flocks, which, with the Buprestidae, are very long; see L. Dufour, loc. cit. III. Pl. XI. fig. 1, 3, 4; Meckel, Beitr. &c. I. Litt. 2, p. 129, Taf. VIII. fig. 5; and Gaede, Nov. Act. Nat. Cur. X. p. 539, Tab. XLI. fig. 1.

With the Dytiscidae, a pretty long and small caecum extends forwards from the rectum; see Ramdohr, Ablauft. &c. Taf. H. I. L. Dufour, loc. cit. III. Pl. X. fig. 3, and Burmeister, Handbuch, &c., I. Taf. X. fig. 4.

See Ramdohr, Ablauft. &c. Taf. L; Marcel de Serrès, loc. cit. Pl. I—III.; Gaede, Beitr. &c. Taf. I. H. (Blatta and Acheta); Suckow, loc. cit. III. Taf. VII. fig. 134—135 (Grilloptera); Burmeister, Handbuch, &c. I. Taf. XI. fig. 6—16; and L. Dufour, loc. cit. XIII. 1828, p. 330, Pl. XX. (Forficula), and his Recherch. sur les Orthopt. &c. loc. cit. Pl. L—V. XIII.

See the figures cited in the preceding note. According to L. Dufour (Recherch. &c. p. 588, Pl. XVII. fig. 190), this gizzard with its dental apparatus is wanting with Termes; but, according to Burmeister (Handb. 1. p. 137, Taf. XI. fig. 8—140), it is present being concealed at the base of the oesophagus.

Grilloptera and Ephippigeria. These caeca are wanting with Forficula and Termes. There are only two with Acheta, Gryllotalpa, Locusta, and Ephippigeria; six to eight with the Mantidae, Blattidae, and Acrididae. In these last, each of these caeca sends off two diverticula, one forwards, and the other backwards.

See Suckow, in Heusinger’s Zeit. II. p. 297, Taf. XVI. fig. 7; L. Dufour, Recherch. &c. Pl. XIII. fig. 108; and Pictet, Hist. Nat. des Névromat. Famille des Peridiae. These caeca are wanting with Nemura.

See Ramdohr, Ablauft. &c. Pl. XV. (Libellula and Aegrota); Suckow, loc. cit. II. Taf. II. fig. 14 (Aschen); L. Dufour, Recherch. &c. p. 588, Pl. XI. (Aschen and Libellula); and Mutter, Nov. Act. Nat. Cur. XII. p. 571, Tab. L (Bacteri). These stomachic appendages are wanting with Pseus also; see Nitzsch, in Germany’s Mag. IV. p. 277, Taf. II. fig. 1.


\(^{[6]}\) See also, Leidy, loc. cit., Flora and fauna within Animals, &c., for full details of the intimate anatomy of the alimentary canal of PASSALUS CORNTUS.—Es.
The predatory Panorpidae, which are rapacious, differ notably from the other Neuroptera, and resemble rather the preceding order. Their oesophagus is short and straight, and, in the thorax, is succeeded by a spherical muscular gizzard which is lined internally with a brown chitinous membrane covered with stiff hairs. The stomach is tubular and straight; the ileum makes two convolutions before passing into the long colon. With the other Neuroptera, namely, the Myrmeleontidae, Hemerobiidae, Sialidae, and Phryganidae, the oesophagus is long, and dilated, posteriorly, into a kind of pouch; and often there is a long, thin-walled, sucking stomach inserted on one of its sides. The proper stomach is of a median length, and is more or less transversely constricted. The two other portions of the digestive canal are very small and straight.

The Hymenoptera, which often sip up their fluid food, have a long oesophagus which dilates into a thin-walled, sucking stomach. With the Vespidae, Apidae, and Andrenidae, this stomach is often only a lateral fold of the oesophagus, and with many Crabonidae, it is attached solely by a short and narrow peduncle. Many species of this order have a rudimentary, callous gizzard, enveloped by the base of the stomach. In the genera Formica, Cynips, Leucospis and Xyphidria, it is very apparent, and consists of a globular, uncurved organ. Those Hymenoptera which are engaged during a long and active life in labors for the raising and support of their young, have a pretty long and flexuous stomach and intestine, and the first has, usually, many constrictions. The Cynipidae, Ichneumonidae, and Tenthredinidae, which, after copulation and the deposition of their eggs, take no further care in the act of reproduction, have only a very short small stomach and intestine.

But the modifications of each of the various portions of the digestive tubes are most prominent with the sucking Insecta, especially with the Hemiptera. The oesophagus of these last is usually short and small, while the stomach is generally very long, and describes many convolutions in the abdominal cavity. This stomach, as to form and structure, may be divided into two or three distinctly-defined portions. The first consists of a glandular ante-stomach which is straight, large, and divided by several constrictions. The second has the form of a long, flexuous canal, whose walls are glandular, and which dilates, at its posterior extremity, into an oval pouch. With the Cicadidae, it forms a kind of loop, its posterior extremity being attached to the ante-stomach with Tettigonia, Cercopis, and

18 Ramdohr, Abhandl., &c. p. 150, Taf. XXVI. fig. 1, and L. Dufour, Recherch. &c. p. 582, Pl. XI. fig. 169.
19 Ramdohr, Abhandl. &c. Taf. XVI. fig. 2, Taf. XVII. fig. 2, 6; L. Dufour, Recherch. &c. Pl. XII. XIII.; and Pietet, Recherch. pour servir à l'Hist. et à l'Anat. des Phryganeses. The Myrmeleontidae and Hemerobiidae, alone, have a spherical callous gizzard situated between the stomach and oesophagus. See Swaneremann, BB. der Nat. Taf. XVIII. fig. 1; Trewiranus, Vern. Schrift. II. Taf. XIV. XVI.; Brandt and Ratzburg, Mediz. Beitr. II. Taf. XXX. fig. 29; Ramdohr, loc. cit. Taf. XII.-XIV.; Suckow, loc. cit. III. Taf. VI. VII. VIII.; finally, L. Dufour, Recherch. &c. p. 383, Pl. V.-X.
20 With Chrysis, and Hedgescrum, this sucking stomach consists of two lateral canals situated at the lower end of the oesophagus; see Suckow, loc. cit. III. Taf. IX. fig. 165, and L. Dufour, loc. cit. Pl. IX. fig. 113, 116.
21 The Apidae, Andrenidae, Vespidae, and Larridae.
22 For the digestive apparatus of the Hemiptera, see Ramdohr, Abhandl. &c. Taf. XXII. XXIII.; Suckow, loc. cit. III. Taf. VII. VIII.; L. Dufour, Recherch. sur les Hémiptères. p. 20, Pl. I.-IX.*
23 Notoneca, Naneoris, Velia, Locaneus, Comtes, Pyrrhocoris, Pentatoma, Pega, Syrmaestes, &c.

* [§ 338, note 23.] For the digestive apparatus with all its details of Belostoma, see Leidy,


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Ledra; and with Cicada, it penetrates even under the muscular tunic of this ante-stomach. (22) With the Pentatomidae, and some Coreidae, there is even a third stomach, quite remarkable, consisting of a very narrow, slightly-flexuous canal, on which are inserted two or four rows of closely-aggregated glandular tubes. (25) The ileum and colon are nearly always fused into a pyriform pouch, upon which is sometimes inserted a kind of lateral caecum. (22) With the Cicadidae, however, the ileum is distinct, narrow, and nearly always very long and flexuous.

The Diptera have a sucking stomach with a more or less long peduncle, inserted upon one of the sides of the short, small oesophagus. This peduncle accompanies the stomach even into the abdominal cavity, where it terminates in a pouch whose thin walls are composed solely of delicate muscular fibres. This pouch is oblong or round, and often divided, heart-shaped, by a deep fissure. (28) The proper stomach is always long and intestinoïd, except at its anterior extremity, where it is often dilated. It is situated in the abdominal cavity and makes many convolutions. In some families, only, there are two lateral caeca inserted near its cardiac extremity. (29) The ileum is small, of median length, and is succeeded by a pyriform colon.

The Lepidoptera, which, in their perfect state, live only upon the juices of flowers, suck up this kind of food by means of a thin-walled, sucking stomach, situated at the anterior extremity of the abdominal cavity, and opening by a short peduncle into the posterior extremity of the small, long oesophagus. (28) The stomach is pretty long and large, often variegate, and always straight. The ileum is long, small, and nearly always forms several anv and two backwards. The Diptera fill this sucking stomach with liquid (honey, blood, &c.), or solid (pollen-grains) substances, but which, certainly, are only there deposited without being changed, for the walls of this organ do not present the least traces of a glandular structure. It is, moreover, remarkable that the Pulcidae and the Hippoboscidæ, which feed exclusively on animal juices, have a kind of crop at the posterior extremity of the oesophagus, but no trace of a sucking stomach; see Ramdohr, loc. cit. Taf. XVII. (Hippobosces and Metalophas.) Also L. Diptera, Ann. d. Sc. Nat. VI. 1839, p. 365; Pl. XIII. fig. 1, and 111. 1848; p. 63, Pl. III. fig. 13 (Hippobosces and Metalophases). With Pulex, the crop is provided with large claws on its internal surface, and thus resembles a gizzard.

[28] See Swammersdam's Bib. der Nat. Taf. XXXVI. fig. 1 (Vanessa anticae); Trexianus, Veran, Schrift. H. p. 103, XL; and Annul. d. Wetteransch. Gesellshch. Heft. 1, p. 147; Taf. XVI. (Vanessa, Sphine, and Dellephia); Suckov, loc. cit. Taf. IX. fig. 101 (Sponnentia); and Newport, Cyclus, loc. cit. fig. 490, 491 (Sphine and Potissa). This sucking stomach is doubled with the Zygaenidae (Ramdohr, loc. cit. Taf. XVII. fig. 1); it is wholly wanting in the Hespidæae, Bombycidæae, and in general all the image Lepidoptera which do not eat. See Trexianus, Veran, Schrift. loc. cit. p. 107, and Annul. d. Wetteransch. Gesellshch. loc. cit. p. 159; Taf. XVI. 1; and Lygnet, Mem. du Mus. XX. p. 285, Pl. XIX. fig. 10.©

* [§ 338, note 30.] See also, for the intimate structure of the intestinal canal and its appendages of Bombux mori (both larva and imago), Fitis.
convolutions. The colon is constantly of a large size, and is often dilated into a caecum at its anterior portion.\(^{31}\)

Among the Apterida, the Nymphidae, Poduridae, and Lepismidae, have, at the posterior extremity of the oesophagus, a kind of crop, which, with

*Lepisma*, is succeeded by a globular gizzard provided with six teeth. The proper stomach has the form of a long tube, and is not flexuous as with the Pediculidae. With these last, and with the Nymphidae, which are parasites, it has, at its anterior extremity, two caeca directed forwards. But the intestine which succeeds it, is very short with all the Apterida.\(^{32}\)

With all the holometabolous Insects, or the Orthoptera and Hemiptera, the digestive canal of the larvae and pupae differs but little from that of the perfect insects.\(^{33}\) With the Coleoptera, the larvae likewise resemble the perfect insects in this respect,—their mode of life being generally the same, as has already been evinced by the structure of their oral organs.

The stomach is usually shorter and larger, and the number of its appendages less, than with the perfect forms.\(^{34}\)

The larvae of the remaining holometabolous Insects, which differ essentially from the imagines as to their oral organs, besides living upon different food, have also a digestive canal so different, that it must undergo a constant and gradual change during the quiescent pupa state.\(^{35}\) Most of these larvae have powerful masticatory organs,—such as those of the Lepidoptera, the Tenthredinidae, the Sireidae, Phryganidae, Sialidae, and the cephalous ones of the Culicidae and Tipulidae.

The digestive canal here is straight and rarely longer than the body; its greater portion consists of a large and usually varicose stomach, while the ileum and colon are pretty short.* With the larvae of the Lepidoptera, the cylindrical ileum is large and divided into six lateral pouches, by as many longitudinal septa.\(^{36}\) But with the cephalous larvae of the Mycetophilidae and Scaridae, and the acephalous ones of the Diptera, the digestive canal is formed upon a wholly different

\(^{31}\) This caecum is found with *Hipparchia*, *Pon-tia*, *Sphinx*, *Gastropacha*, *Euprygia*, *Acidalia*, *Caberia*, *Aedes*, *Chilo*, and *Tinea*. It is wanting with *Vanessa*, *Zygaena*, *Hippolais*, *Cossus*, *Ipos- nometa*, and *Pterophora*.

\(^{32}\) See Nitsch, in *German's Magaz. d. Entom. III. p. 209 (Nymphidae); *Nicolet*, loc. cit. p. 45, Pl. IV. fig. 2 (Poduridae); *Swammerdam*, Bib. der Nat. p. 33, Taf. II. fig. 3; *Rambour*, loc. cit. p. 352, Taf. XVI. fig. 3, and Taf. XXIV. fig. 4, and *Prostrianus*, Verm. Schrift. II. p. 23, Taf. III. fig. 1-6 (Pediculus and Lepisma).

\(^{33}\) See Suckow, in *Heisinger's Zeitsc. II. Taf. I. fig. 6 (Ascesina), and Rathke, in *Muller's Arch. 1841, p. 55, Taf. II. fig. 4 (Griletolaphus)*.

\(^{34}\) With the larvae of Calosoma, the stomach is straight and without caeca (Burmeister, Trans. of the Entom. Soc. 1. p. 260, Pl. XXIV. fig. 16, 11).

\(^{35}\) With *Hydrophila obliqua*, and *Dytiscus marginatus*, it is varicose, slightly tortuous, and without caeca (Suckow, in *Heisinger's Zeitsc. II. Taf. IV. fig. 25, and Burmeister, Hamb. I. Taf. X. fig. 3). The larvae of the Lampyridae, *Hydrophilae*, most of the Coleoptera, differ but little from the imagines as to their digestive canal (*L. dufour*, Ann. d. Sc. Nat. III. 1824, Pl. XI. fig. 7 (Lampyris); *Dist. XII.* 1840, Pl. V. fig. 5 (Porçyon); *XIV.* 1840, Pl. IX. fig. 9 (Mar detta) and *Burmeister, Nat. Naturg. d. Osländs*, p. 9, fig. 3). The most marked difference between the larvae and the imagines, is observed with the Lamellicornes. The first have a very spurious, straight stomach, which, at both extremities and sometimes also in the middle, has a circle of simple or varicose, thickly-set caeca; the ileum is very short, and the large intestine extremely large and always bent forwards; see Roesel, Insektenkunst. II. Taf. VIII. IX.; *Suckow*, loc. cit. III. Taf. III. fig. 97 (Meliphaga) and *L. dufour*, Ann. d. Sc. Nat. XVIII. 1842, Pl. IV. fig. 8, Pl. V. fig. 18 (Cetonia and Dorcus); finally, the excellent work of *De Hémar*, sur les metamorphoses des Coleoptères, Mém. 1. les Lamellicornes, in the Nouv. Ann. du Mus. 1855, p. 153, Pl. XVI.—XIX.

\(^{36}\) For this metamorphosis of the intestinal canal, see *Dutrochet, Jour. de Physique*, etc., LXXVI. 1818, p. 130, or *Meckel's deutsch. Archiv* IV. p. 285, Taf. III. (*Hymenoptera, Aphis, Polistes, Tenthredo et Erismidae*). This metamorphosis with *Sarcophaga harnackioides* has been described and figured by *L. dufour*, in *Memoires*, etc., IX. p. 580, Pl. III. See *Sawamdermann*, Bib. der Nat. Taf. XXXIV. fig. 4; *Lyonet*, Traité, etc., Pl. XIII.; *Rambour*, loc. cit. Taf. XVIII. fig. 8. Many naturalists have carefully observed the metamorphoses of the digestive canal with the Lepidoptera; see *Hérol*, Entwicklungs-geschichte d. Schmetter. Taf. III. fig. 1-12 (*Pontia brucei*); *Suckow*, Annt. physiol. Untersuch. p. 24, Taf. II. fig. 1-10 (*Gastropacha pinus*); and *Neupert*, Philos. Trans. 1854, Pl. XIV. fig. 11-15 (*Sphinx ligustri*). This last author has figured the digestive canal in *sita* in all the three states.
plan. It exceeds more or less the length of the body, and there is a crop at the posterior extremity of the oesophagus upon which succeeds a long and tortuous stomach. Upon the cardiac portion of this last there are inserted two to four caeca directed either forwards or backwards, and with some larvae of the Museidae, there is also a long, sucking stomach upon one of the sides of the oesophagus.\(^\text{25}\)

With the larvae of the Neuroptera, which suck up their liquid food through tubular mandibles, the posterior extremity of the oesophagus is dilated into a pyriform sucking stomach, which is followed by the proper stomach, large, of median length, and slightly flexuous. The extremely small ileum is long and makes several convolutions, while the colon is large, vesicular, and continuous into a horny tubular rectum.\(^\text{26}\)

\[\text{§ 339.}\]

As to the granular appendages of the digestive canal of the Insecta, the Salivary Organs are quite widely distributed, as well with the Imagines as with the Larvae and feeding Pupae. These organs consist of one, or two, rarely three pairs of colorless tubes of unequal length. These are sometimes prolonged into the thorax, while in other cases they accompany the digestive canal into the abdominal cavity where it makes many convolutions. Their excretory ducts are composed of a solid membrane, and are distinctly separated from the granular portion.\(^\text{27}\) This last is composed of three layers, namely: an external, homogeneous envelope,—an intimate tunic accompanying the excretory duct,—and a middle layer composed of colorless, glandular, nucleated cells, which often form very fine excretory tubes opening into the common duct. Frequently, also, these ducts contain a spiral filament like the tracheae; they open, each, at the base of the oral cavity by a distinct orifice, and it is rare\(^\text{28}\) that they unite, forming a common duct; sometimes they have, near their excretory openings, special salivary reservoirs.\(^\text{29}\) With very many Aptera,\(^\text{30}\) Diptera, Lepidoptera, and Coleoptera,\(^\text{31}\) the salivary organs consist of two simple tubes, which, with the larva of the second and third of these orders, often extend a considerable way into the abdominal cavity.\(^\text{32}\)

\(^{37}\) See Swammerdam, Bib. der Nat. Taf. XLI. fig. 6, Tab. XLIII. fig. 5 (Stratiomys and Piophila); Ramdohr, loc. cit. Taf. XIX. fig. 1 (Musca); L. Dufour, Ann. d. Sci. Nat. XI. 1833, p. 312. Pl. V. fig. 23. XII. p. 13, Pl. L. fig. 1, 4, and L. 1844, p. 372, Pl. XVI. fig. 8 (Ceroplatus, Sapromyza, Piophila).

The metamorphosis of this digestive canal, in the pupa of Sarcophaga carnaria, is represented in a suite of figures published by Suckow, in Heinseger's Zeitsch. III. Taf. IX. fig. 147-155. But Suckow has fallen into the same error as Ramdohr (loc. cit. p. 171) in regarding the excaal appendages of the stomach of the larva as four tubes connecting the stomach with the salivary canals.

\(^{38}\) See Ramdohr, loc. cit. p. 154, Taf. XVII. fig. 1; and L. Dufour, Recherch. &c. p. 559, Pl. XII. fig. 175 (Hymenoptera). The large intestine together with the rectum, does not serve, with this larva, as a digestive organ, but, as is very extraordinary, has the function of a Spiniuscret (see § 347).

1 For the intimate structure of these organs, see H. Meckel, in Muller's Arch. 1846, p. 25, Taf. 1. II.

2 Piophila, Musca, Sarcophaga, Tabanus, Hippobosca, Oestrus, Mordella, Mantis, and Forficula.

3 With Forficula, Musca, Sarcophaga, and Hippobosca, each of these excretory ducts is dilated into a roundish reservoir; but with the Termitidae, Acrilidio, Achatidae, and Mantidae, there is an oblong, pedunculated reservoir common to both ducts. See, for the figures, the various memoirs of L. Dufour.

4 With the Nirmidae.

5 Pyrochros, Lixus, Phylaibos, Diaperis, Lema, Oedemera, Chrysomela, Coccinella. In this last genus, the two salivary vessels are toro.

6 See the figures in the works of Swammerdam, Lycomet, Ramdohr, Suckow, Herold, and L. Dufour.
nebrionidae, Mordellidae, and most of the Hymenoptera, they consist of two rather short, ramified tufts, often contained entirely in the head. Among the Neuroptera, the Myrmeleonidae and Sialidae have two simple short salivary tubes, while, with the Phryganidae and Hemerobidae, they are ramified and highly developed. It is quite remarkable that there is, in this respect, a sexual difference with the Panorpidae; the males have three pairs of very long, tortuous tubes, while with the females, the only vestiges of this apparatus are two indistinct vesicles. Among the Orthoptera, the salivary organs are entirely absent with the Libellulidae, and Ephemeridae. On the other hand, they are highly developed with the Achetidae, Acrididae, Locustidae, Mantidae, Blattidae, Termitidae, and Periidae, where they consist of two, four, or six botryoidal masses of vesicles, situated in the thorax, and having long, excretory ducts, beside, also, often long-pedunculated pyriform reservoirs. Among the Hemiptera, these organs are absent with the Aphididae and the Psyllidae; but, on the other hand, they are very large and of a remarkable structure with the Bugs and Cicadidae. Here they are nearly always lobulated, and are divided by a constriction into two portions, of which the upper is much smaller than the lower, and often both have long digitiform processes. The excretory duct divides, immediately after its origin, into two special canals of equal or very unequal length, which extend, serpentine, first, into the abdominal cavity, and then ascend to the mouth. Beside these two constricted glands, many Bugs have, also, one, rarely two pairs of simple salivary tubes, which are often dilated, vesiculiform, at their extremity. The salivary organs of the musical Cicadidae differ in many respects from those of the others of this family; for, beside the two simple tortuous tubes, there is, in the head, another pair of glands, composed, each, of two tufts of short, cylindrical caeca, situated one behind the other. It is yet undetermined

7 See L. Dufour, Ann. d. Sc. Nat. IV. 1834, Pl. XXIX. fig. 4, 5, XIV. 1840, Pl. XI. fig. 16.
8 See L. Dufour, Recherr. &c. p. 336, fig. 48, 72, 100, 148 (Apis, Andrena, Philanthus, and Xyphidia).
9 With the Coleoptera, the ramified glands end in long, tortuous caeca; while with the Hymenoptera, their extremities are vesiculiform, thereby giving the whole gland a botryoidal aspect.
10 See L. Dufour, Recherr. &c. p. 563, fig. 179, 184, 191, 192, 208, 209 (Myrmeleon, Stilais, Hemerobius, and Phrygaena).
11 See Brants, Tischehr, voor natuurl. Geschied. en Physiologie, 1830, p. 173; and L. Dufour, Recherr. &c. p. 582, fig. 169 (Panorpae).
13 For the salivary organs of the Hemiptera, see, beside Ramdahr, loc. cit. Taf. XXII. XX111, especially L. Dufour, Recherr. sur les Hemiptera, p. 115, Pl. 1.-X.
14 The two excretory ducts are of the same length.
15 {§ 330, note 12.] See also Leidy, loc. cit. p. 82 (Spectrum femoratum.)—Ed.
16 [§ 332, note 14.] With Belostoma, the salivary glands are four in number, are of conglomerate structure and situated on each side of the esophagus into the commencement of which they empty. Two of them are long and extend backwards as far as the commencement of the abdomen; while the other two are about one-fourth as long: Beside these, on each side of the esophagus, there is situated a sigmoid caecal pouch which opens by a narrow duct into the commencement of the esophagus in the vicinity of the termination of the salivary ducts: these are perhaps reservoirs of the saliva; see Leidy, loc. cit. p. 63. —Ed.
The Insecta have no distinct Hepatic Organs, but the function of a Liver is performed by the walls of the stomach, the internal tunic of which is composed of closely-aggregated hepatic cells. With many species whose stomach has coenac appendages, the walls of these last have a similar hepatic structure, and must secrete, therefore, a bile-like fluid.\(^\text{19}\)

With some Insecta, the ileum has glandular appendages, whose product is perhaps analogous to a pancreatic fluid. The two or four rows of follicles which, as before mentioned, are situated on the ileum of the Pentatomidae and some Coreidae, would, in the same manner, be regarded as a Pancreas. The same remark applies to the ramified appendages, which, with Gryllotalpa, open into the stomach below the two ceca, as well, also, to the two or three follicles which, with Pyrrhocoris, are inserted, laterally, on the posterior part of the ileum.\(^\text{19}\)

There is found, with all Insecta, a Corpus adiposum, — a tissue, composed of adipose cells, which is intimately connected with the functions of digestion and assimilation. This body is especially developed towards the end of the larval state, and it disappears, for the most part, during the pupa period, so that only a few traces of it are found with Insecta in their perfect state. It is usually of a white, or a dirty-yellow color, but is also observed of a green, red, or orange hue. In the larvae, the fat cells generally form pretty large, lamelliform lobes, sometimes ramified or reticulated, sometimes plicated, spread through the abdominal cavity in all the intervals of the visceræ. These lobes are always traversed and retained in place by numerous trachean branches. With the perfect Insecta, the remains of this body are not usually found except in the posterior portion of the abdominal cavity, where they consist of fat-cells loosely scattered, and not retained by the tracheæ.\(^\text{20}\)

\(^{19}\) For these biliary organs, see J. Müller, De Gland. struct. p. 67. The Malphigian vessels which were formerly regarded as biliary tubes, will be treated of in future (§ 340).\(^\text{19}\)

CHAPTER VI.

CIRCULATORY ORGANS.

§ 340.

The Circulatory System is feebly developed with Insecta, consisting of a contractile, articulated *Vas dorsale,* and a cephalic *Aorta.* The first serves as a heart, and the second is a simple conductor of the blood from the heart into the body. In both of these vessels, the blood moves from behind forwards, and, at its escape from the aorta, traverses the body in all directions, forming regular currents which have, however, no vascular walls. In this way, it penetrates the antennae, the extremities, the wings, and the other appendages of the body, by arterial currents, and is returned by those of a venous nature. All the venous currents empty into two lateral ones running towards the posterior extremity of the body, and which enter, through lateral orifices, the dorsal vessel. [1]

1 Summerer, Dam, malphigi, and others of the older anatomists, had already formed a pretty exact idea of the circulation of the Insecta. But, subsequently, it was entirely abandoned when it was observed that the dorsal vessel was a closed tube, and served only as a simple reservoir of the nutritive juices. *Carus* was the first to demonstrate anew the existence of a circulation which has since been confirmed with all the three stages of insects. See *Carus,* Eschbeck, eines einfachen, vom Herzen aus beschleunigten, Blutkreis in den Larven nachweislich. Insect. 1827; *Nov. Act. Acad. Nat. Cur. XV.* part II, p. 8. Taf. LII. and *Lehrbuch d. vergleich. Zoöl.* 1834, p. 687; *R. Wagner,* 1844, p. 229, 773; *Barnes,* *Handb.* etc. I. p. 104, 436; *Bouyer-Baudot,* Entom. Mag. I. 1833, p. 230, IV. 1833, p. 173 (also in *Frontier's* new *Nat. XXIX.* p. 119); *Tyrrell,* *Philosoph. Trans.* 1835, p. 317; *Newp.,* *Cyclop.* &c. II. p. 968; *Milses* *Edwards,* *Ann. d. Sc. Nat. III.* 1848, p. 275; and *Quaterf.,* Insect. 1849, p. 365. This circulation carried on by the dorsal vessel, having been observed by so many distinguished naturalists, it is truly impossible to suppose that *L. Dupoir* (*Recherch. sur les Hymèpt.* p. 272; *Recherch. sur les Arach.* p. 357; *Ann. d. Sc. Nat. XVI.* 1841, p. 10; Mem. présents à *Hist.* IX. p. 35, 59) can persist in denying that the dorsal vessel is anything but a secretory organ, which, according to him, has no opening and therefore nothing in common with a heart. He cites the authority of *Couvier* who was unwilling to accord to the *Vas dorsale* either the name or the functions of a heart (*Couvier,* *Mém. sur la manière dont les larves de divers insectes sont myrmécophiles,* p. 516; *la nature des rapports de la circulation dans les insectes,* in the *Mém. d. L. Soc. d'Hist. Nat. de Paris,* VIII. 1793, p. 51, or *Elève de l'Arch. V.* 1857). *L. Dupoir* observes, moreover, in support of his erroneous view, the following remark of *Carus* (*Erflaubung*, Hft. VI. p. 87), "In the perfect Insecta, whose respiration is performed by a system of tracheae traversing the entire body, the circulation of blood would be useless." But to this it may be replied, that *Carus,* by these words, has contradicted his proper observations; for he has shown that there is a circulation in many perfect insects, as is stated not only in the *Nov. Act. Nat. Cur.,* but, also in the *Erflaubung,* from which the above citation was taken. At all events, the proposition of *Carus* is correct, "that in insects, the blood must come in contact with the atmospheric air, which is accomplished by means of the tracheal system." But this applies only to the small portion of the circulation connected with the respiratory process; whereas, the larger portion, destined for the general nutrition of the insect, does not evidently require the presence of tracheae. The presence of a real blood-circulation by means of the *Vas dorsale,* is so easily observed, that the injections of *Blanchard* are scarcely necessary (Compt. rend. XXIV. 1847, p. 567).

If, in certain species, although transparent, these phenomena are not observable, we must not be too hasty in denying its real existence, for the blood, which is not visible except through its globules, is often so poor in these last, as to make our observation impossible. *Vesorta* has recently given a very complete résumé of what has been done on this subject, and has added new and confirmatory observations; see *Holländische Beitr. zu den anat. und. physiol. Wissensch.* 1. Hft. 2, p. 220; and *Mémoire sur la question suivante,* editer par des observations nouvelles le phénomène de la circulation dans les insectes, en recherchant si peut la ressemblance dans les larves des différents ordres de ces animaux, in the *Mém. d. L. Soc.* 1854, 1857.
The Blood of the Insecta is usually a colorless liquid, though sometimes yellowish, but rarely red.\(^2\) In this liquid are suspended a few very small, oval, or spheroidal corpuscles, which are always colorless, have a granular aspect, and are sometimes nucleated.\(^3\)

The Dorsal Vessel, which is constricted at regular intervals, is always situated on the median line of the abdomen, being attached to the dorsal wall of its segments by several triangular muscles whose apices point outwards. Its walls contain both longitudinal and transverse fibres, and, externally, are covered by a thin peritonal tunic. Internally, it is lined by another very fine membrane, which, at the points of these constrictions, forms valvular folds, so that the organ is divided into as many chambers as there are constrictions. Each of these chambers has, at the anterior extremity on each side, a valvular orifice which can be inwardly closed.\(^4\)

The returning blood is accumulated about the heart and enters into it during the diastole of each of its chambers, through the lateral orifices.\(^5\) It then passes, by the regularly successive contractions of the heart, from behind forwards into the aorta which is only a prolongation of the anterior chamber. This aorta consists of a simple, small vessel, situated on the dorsal surface of the thorax, and extending even to the cephalic ganglion, where it either ends in an open extremity, or divides into several short branches which terminate in a like manner.\(^6\) The length of the dorsal vessel depends, in all the three states of insects, upon that of the abdomen. The number of its chambers is very variable, but is, most usually, eight.\(^7\)

The blood, after leaving the aorta, traverses the body in currents which

\(^2\) The blood is red in many larvae of Chromonurus.


\(^4\) For the structure of the dorsal vessel, see Strass, Consid. c. p. 356, Pl. VIII. (Melanolomtha variatae); Wagner, Isis, 1852, loc. cit. Tab. II. (larvae of Dippia and Ephemerides), and in Mulder's Arch. 1855, p. 531, Tab. V. (larva of Corethra plumicornis); Newport, Philos. Trans. 1843, p. 272, and Cyclop. loc. cit. p. 976, fig. 433, A. and 434 (Locanus cervus and Asillus erubri-formis); finallyLIMITEN, Mem. loc. cit. p. 31, Pl. III.-VIII. (Chromonurus, Sphinx, Rhyncho-phorus, Pompilus, Syrphus, and Vespa). The constrictions of the dorsal vessel are feebly marked with the larvae of Dippera and Hymenoptera.*

\(^5\) According to Newport (Cyclop. loc. cit. p. 977), the space in which the blood accumulates about the heart is surrounded by a very thin membrane, and may therefore be regarded as a true auricle.

\(^6\) The Aorta is divided at its extremity with Metoce, Ilips, Timarcha, Vanessa, and Sphinx; see Newport, Cyclop. loc. cit. p. 978.

\(^7\) With the Orthoptera, Lepidoptera, and their larvae, as also with various larvae of Dippera. It is rare that the number of chambers exceeds eight, as, for example, with the Podaridae (Nicolet, loc. cit. p. 50, Pl. IV. fig. 3). More commonly there are seven, as with Locanus and Dytiscus (Newport, Cyclop. loc. cit. fig. 433, A. and Wagner, Icon. Zool. Taf. XXIII. fig. 2). Burmeister (Manthl. 1. p. 165) has observed only four with the larva of Callonea.
are always extravascular, and in this way bathe all the organs. The newly-prepared nutritive fluid passes through the walls of the digestive canal in which it is found, into the visceral cavity, and thence directly into the blood. Latterly, this extravascular circulation has been called in question, but its presence may be easily and directly observed with very many perfect Insecta and their larvae. The vascular walls supposed to have been seen at certain points, are, undoubtedly, the result of some error of observation or interpretation. This is also true of the pulsatil organs supposed to have been observed in the legs of many water-bugs, and which were thought to affect the circulation.

CHAPTER VII.

REPRODUCTIVE SYSTEM.

§ 341.

The Insecta respire, in all their conditions of life, by means of a system of Tracheae which are spread through the entire body and penetrate all the organs. This system of air-vessels either opens externally by stigmata through which the atmospheric air is introduced directly, or they have no external communication, but derive the air from the water by means of lamelliform or tubular prolongations with which the tracheae terminate, and which have often been compared to branchiae. In the first case, they are called Pulmonary tracheae, and in the second, Branchial tracheae.

8 In the antennae, the legs, the filaments of the tail, and other appendages, the arterial and venous currents are contiguous. But in the wings they are isolated, and although they may be observed in the nerves of the wings, yet these last should not therefore be regarded as true blood-vessels, for their cavities are only prolongations of the visceral cavity, as is shown by the fact that they are sometimes traversed at the same time by branches of tracheae. In the memoir of Pertoren (loc. cit. p. 70) will be found a very complete account of all the reasons opposing the presence of vascular walls in Insecta.

9 The same should probably be said about the thin walls which Bomerbank, and Newport (loc. cit.) think they have observed with Ephemera concerning the two lateral currents which run towards the posterior extremity of the abdomen. Another vessel which, according to Treviranus (Zeitsch. l. Physiol. IV. p. 152, Taf. XIV, fig. 13) and Newport (Philos. Trans. 1834, p. 335, Pl. XIV, fig. 9, and Cyclop, loc. cit. p. 983), is found in the larvae and imagines of Lepidoptera above the gastricul chain, and is the analogue of the supraspiral artery of the Myriapoda (§ 254), requires further research, for it may be questioned if such an organ, found only in certain groups of Insecta, is really a vessel.

10 Very dissimilar and contradictory opinions have been published on these pulsatil organs. Behn (Müller's Arch. 1835, p. 554, Taf. XIII, fig. 13, 14, or Ann. d. Sc. Nat. IV. 1835, p. 5) has described them with Cortiza, Placa, Naucoris, Nepa, and Ranatra, as thin, movable lamellae attached to the inner wall of the trachea. Pertoren (Mem. loc. cit. p. 82, Pl. VI, fig. 24, 25) has confirmed these observations with the Cicadidae, although neither L. Dufour (Ann. d. Sc. Nat. IV. 1835, p. 337) nor Wesmael (Ballet de l'Acad. de Bruxell. III. p. 155) has been able to discover them in the water-bugs above cited. It is possible that these apparent pulsations are produced simply by the contractions of neighboring muscular fibres.

1 See Burmeister (Handb. d. p. 179; Lepidoptera, Introduct. &c. II. p. 89; and Newport, Cyclop, loc. cit. p. 983). These organs have not the structure of true branchiae, and the blood is not subjected in their interior to the respiratory act, as is shown by the small quantity of this fluid which traverses them. These false branchiae are evidently designed to receive air, or, to speak more properly, to act, through cutaneous and exoesmal, in the transformation of air from the water into the tracheal system. Dugas (Traité de Physiol. II. p. 540) is therefore correct in terming them Branchies tracheales.
THE INSECTA.

§ 342.

The tracheae are cylindrical tubes of variable size, which often form, in their course, vesicular dilatations and numerous anastomoses. They divide, like blood-vessels, into many branches which gradually decrease in size, ending, at last, caecally, so that the expired air passes out by the same way that it entered.

The intimate structure of these organs is remarkable, and has always attracted the attention of anatomists. When filled with air they present a beautiful, silver appearance. Externally, they are invested with a thin transparent, colorless, or very rarely brownish membrane, corresponding to a peritonal envelope. Internally, they are lined with another membrane still finer, which presents a lamellated epithelial structure. Between these two membranes is situated a solid spiral filament whose turns are usually near together. This filament is sometimes cylindrical, sometimes flattened, usually transparent and colorless, and in a few instances only, of a dark color. Often, its course is unbroken for a long distance, and rarely is its extremity forked. The new threads always begin between the turns of the preceding one, as may be easily observed at the commencement of each tracheal ramification. In the ultimate tracheal branches, these threads gradually decrease in size, and at last become indistinct. In the vesicular dilatations of the tracheae, with many Insecta, the spiral thread is often wholly wanting.

§ 342.

The Branchial tracheae are found only in certain aquatic larvae and pupae, and never in the perfect Insecta. The absence of stigmata here is compensated by the existence of false branchiae (Branchiae spuriae seu tracheales), which are cylindrical, or riband-like organs covered by a very

2 For the internal structure of the tracheae, see, besides the works of Burmeister, Lacordaire, and Newport, that of C. Sprengel, Comment. de partiis, quibus Insect. spiritus ducent, 1815; Stackh. in Hesseger's Zeitsch. 11. p. 24, Tab. 1. fig. 10; Sturm, Const. 1. p. 518, Pl. VI. fig. 5; Newport, Philos. Trans. 1836, p. 520; and Platner, in Müller's Arch. 1844, p. 38, Tab. 111.

3 This membrane is brown in the Lilibellidae and Locustidae; this coloration is due to a finely-granular substance contained in the membrane.

4 See Platner, loc. cit. Most anatomists regard this internal membrane as mucous. This being admitted, it was very natural to suppose that it, like that of the lungs of the Vertebrata, is covered with cilia. But here, as well as in other regions of the body of insects, there is no trace of ciliated epithelium, which, indeed, would be incompatible with the presence of chitin. Peters (Müller's Arch. 1841, p. 233) was certainly deceived when he thought he observed ciliary movements in the tracheae of Lamprota, Conceinula, Musca, and other Insecta. He has himself admitted that he was not able to distinguish the cilia. For my part, I have sought in vain for this movement in the tracheae, and Stein (Vergleich. Anat. u. Physiol. d. Insect. 1847, p. 105) has been equally unsuccessful.

5 The tracheae of the larvae of the Dytiscidae owe their black color to the spiral filaments.

6 With the Munoidea, Syrphidae, Vespidae, Apidae, and Meloididae.

* [§ 341, end.] See, also, for investigations upon the intimate structure of the tracheae, Dujardin (Comp. rend. 1849, p. 621), and Mayer (Ueber die Entwickelung des Fettkörpers, der Tracheen, &c., loc. cit., bei den Lipopterern, in Siebold and Kii1ker's Zeitsch. I. p. 175). The views of Dujardin are different from those usually received, for he regards the spiral thread not as a special formation, but only a fold-like thickening of the internal membrane, which membrane is not composed of cells but is a structure analogous to the wing-membrane, and is covered with hairs and points. On the other hand, Mayer, who has studied the embryonal development of these organs, states that the spiral thread is originally a homogeneous membrane, which ultimately splits up into the threads. This subject of the structure of tracheae has now an additional point of interest, from its relations to Blanchard's views of a peritropical circulation in the Insecta. In this connection see especially Filippi (Annali della R. Accad. d'agricoltura di Torino, V., also Wiegmann's Arch. 1851, Th. II. p. 145). — Bn.
thin cutaneous membrane, and containing one or several finely-divided tracheal trunks. These tracheal branchiae are either isolated, or fasciculated; in this last case, they are often digitiform, or penniform, and their ultimate ramifications are usually deficient in the spiral filament. All the air-vessels which these branchiae contain, arise from the larger tracheal trunks. These branchiae occur with various Tipulidae, with a Nymphula, with the Phryganidae, Sialidae, Ephemeridae, Perlidae, Libellulidae, and with the Gyrinidae.

This tracheal system is most simple with the larvae of Tipulidae of the genera Chironomus, Tanypus, Corethra and Simulia, as also with some larvae of the Phryganidae, of the genera Rhyacophila and Hydropteryx, where the tracheae, instead of forming cutaneous appendages, are subcutaneous and can therefore extract air from the water. The larvae of Corethra are distinguished for having in the thorax and abdomen, directly beneath the skin, two adjacent tracheal vesicles, by means of which, very probably, the necessary renewal of air takes place. With the pupae of Simulia, there are two branchial tufts on the sides of the prothorax, composed, each, of six to eight long caecal tubes, which contain each a single simple tracheal tuft in the spiral thread. Of the various larvae of the Lepidoptera, living under the water, that of Nymphula stratiotes, alone, has branchial branchiae. These consist of fasciculate filaments situated on the sides of the abdominal segments. With the larvae of Sialis, each of the six, seven or eight abdominal segments has upon its sides an articulated, filiform thread, containing a tracheal vessel, and which may, therefore, be regarded as a tracheal branchia. Most of the larvae and pupae of the Phryganidae, have, at the same points, one or two filiform, tracheal branchiae, rarely ramified, and united in groups of from two to five, which stand out towards the back. With those of the Ephemeridae, each of the anterior abdominal segments has a pair of these branchiae which are sometimes ramified in the most varied manner, and sometimes consist of two kinds, some being lamelliform and alternating with the others which are fasciculate. With all the Ephemeridae, these organs have movements which are sometimes slow and rhythmical, and sometimes rapid and oscillatory.

With the Perlidae, the branchiae are filiform, ramified, and situated on the three thoracic segments of the larva and pupa, or bound together in several short fasciculi which cover the base of the legs.

Among the Libellulidae, the larva and pupae of Agrion and Calo-
pteryxz are distinguished for having three long, lamelliform branchiae, with a rounded extremity, and situated vertically upon the posterior part of the abdomen. (8)

The tracheal branchiae of Aeschna, Libellula, and the other Libellulidae, are formed upon a wholly different plan. They are situated in the very large rectum, and consist of numerous epithelial folds which are traversed by a great number of very fine branches of many large tracheal trunks. The rectum, moreover, invested by a very highly-developed muscular tunic, and its orifice has three pyramidal valves which regulate the entrance and the escape of the water required for respiration. (9) Finally, the larvae of Gyrinus have a pair of long branchiae upon the sides of each of the first seven abdominal segments, and two pairs on those of the eight. (10)

§ 343.

The tracheae most universal with Insecta are those termed Pulmonarv, which are characterized by the presence of stigmata (Spiracula). These last are round orifices or narrow two-lipped openings, situated at various points on the external surface of the body, and which, with many soft-skinned Insecta, are surrounded by a horny ring. Usually, their borders are fringed with small, short, simple or pinnate hairs, (11) and can be opened and shut by means of an internal muscular apparatus; this last is sometimes attached to two inwardly-projecting horny plates. By these means, many Insecta have well-marked respiratory motions, especially of the abdomen. (12)

With the larvae of the Lamellicornes, the stigmata have a peculiar organization. They are closed by a horny membrane whose semilunar borders are cribriform for the free passage of air. (13)

The larvae of the Oestridades have two large stigmata, covered each by a similar plate or membrane, at the extremity of the abdomen; and with some larvae of the Muscidae, the posterior stigmata are closed in the same manner, excepting that the membrane is perforated by three very distinct openings.

Each stigma is usually the entrance of only a single tracheal trunk.

8 Roesel, Insectenbelust. ii. Insecta acquatica, Class. ii. Taf. IX. XI.; and Carus, Entdeck. &c. Taf. i.
9 Roesel, loc. cit. Taf. iii.-viii. and Suckow, in Heuser's Zeitsch. ii. p. 36, Taf. i. ii.
10 Roesel, loc. cit. iil. Taf. XXXI. and Degeer, Mon. IV. Taf. XIII. Further researches are required to decide if the penniform appendages, situated on the sides of the abdominal segments of certain larvae of the Hydrophilidae, are really tracheal branchiae. But it appears to me that, with these larvae, the pulmonary and tracheal branchiae are combined; see Roesel, Insectenbelust. ii. Insect. aquat. Class. i. Taf. iv. and Lygnet, Mem. du Mus. XVIII. Pl. XXIII. (12), fig. 47 (Hydrophilus caraboides).
12 The Lecithidae, Libellulidae, and other Orthoptera, make true movements of inspiration and expiration, by alternately dilating and contracting the abdominal segments. With the Apidas, Vespidae, and other Ilmenoptera, the alternate constrictions and dilations of the abdominal cavity are due to the protractile and retractile movements of the abdominal segments. Many Lamellicornes make these respiratory movements before flying, probably that they may fill their tracheal system with air. (13) Sprengel (loc. cit. p. 9, Tab. i.) has described very correctly the stigmata of the Lamellicornes. Trevisanum (Die Erschein. and Gesetze d. Organ. Lebens, l. p. 258) thinks that these lamellae are not perforated and that the air enters these tracheae by endosmosis, although Burmeister (Handb. &c. i. p. 172) says he has observed a single central opening. I have been unable to confirm the statement of Sprengel, and think that these perforations might easily cause the observation, from their being concealed beneath a kind of net-work on the external surface of these lamellae. L. Dufour (Ann. d. Sc. Nat. XVIII. 1842, p. 173, Pl. iv. fig. 7) has also misapprehended the stigmata of the larvae of Cetonia; for that which he has described as a transverse fissure is only a fold, due to a pressure exercised during the manipulation, on the horny lamella which normally is convex and imperforate in its centre.
which ramifies more or less directly; sometimes, however, several trunks arise from the same stigma.\(^4\)

With perfect Insecta, the stig mata are nearly always situated on the sides of the body in the membrane connecting the two segments, being always wanting, however, in the membrane which unites the head and prothorax, and that between the last two abdominal segments. In many cases, they are covered by the borders of the segments. With the Coleoptera, the stig mata are often situated so high upon the back as to be concealed by the elytra.\(^5\) The number and position of the stig mata vary infinitely, and are not invariable in the different conditions (larva, pupa and imago) of even the same species. These variations are the least with the hemimetabolic Insecta. But among the Hemiptera, the Nauroidae and Nepidae form a remarkable exception in this respect. They have, excepting those of the thorax, only two stig mata at the posterior extremity of the abdomen, and which alone serve, probably, for respiration when these insects are in the water; with Nepa, and Ranatra, these anal stig mata are situated at the base of a long tube formed by the union of two semicannulae.\(^6\) The smallest number of stig mata, consisting of two situated adjacently at the posterior extremity of the abdomen, occurs with the larvae of the Dytiscidae, Stratiomydae, Conopidae, and some Tipulidae and Tachiniaeae. Sometimes these two stig mata are situated at the extremity of a longer or shorter Respiratory tube (Siphon), surrounded by a circle of stiff or penniform bristles. In some cases this siphon is very long and articulated, and can be intussuscepted like the tubes of a telescope.\(^7\) When these Insecta become pupae, these stig mata are sometimes remarkably modified. The pupae of Culex lose their anal siphon, and acquire, instead, two others which are infundibuliform and situated laterally between the prothorax and mesothorax.\(^8\) The pupae of Ptychoptera respire by means of a flexible siphon situated in the neck.\(^9\) With the Strepsiptera, the male, as well as the apodid female

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\(^4\) In the larvae of the Lamellibranches; see Sprengel, loc. cit. Tab. I. fig. 1 (larvae of Geotrupes). Some Coleoptera are present, in their perfect state, a very singular organization in this respect. Their thoracic stig mata send off not only several large tracheal trunks, but also an infinite number of small branches; see Pictet, Mém. d. l. Soc. d. phys. &c. de Genève, VII., 1836, p. 343, fig. 5, 6 (Homallederus heros), or Ann. d. Sc. Nat. VII. 1837, p. 65.

\(^5\) From this arrangement, the Dytiscidae and Gyrinidae, which live in the water, must, in order to breathe, emerge the posterior part of their body to draw fresh air under their elytra, whence it is taken into the tracheae. The Notonectidae, Hydropsiphidae, Paridae, and other aquatic Coleoptera, respire under the water by means of a provision of air which, after their immersion, adheres to the hairs of the legs. With Hydrophilus, the renewing of this air occurs in a very remarkable manner. They protrude only their antennae out of the water, and, bending them backwards, thus establish a communication between the external air and that adhering to the under surface of the body; see Nitzsch, in Reil's Arch. II. p. 446, Tab. IX.

\(^6\) See Roset, Essaisemblostaw. III. Tab. XXII., XXIII.; and L. Dufour, Recherches, sur les Hyméopt. p. 244, PL XVII. fig. 195, PL XVIII. With Nepa, it is true: there are stigmate-like rings on the other abdominal segments, but they are closed, and L. Dufour has properly called them false stig mata. In the young age of these insects these false stig mata are open and situated in two pilose grooves located under the belly at some distance from the lateral borders, and which are prolonged even to the end of the siphon, where they blend into one. The air is conducted by these grooves into the stig mata.

\(^7\) By this disposition of the stig mata, the larvae of the Dytiscidae, Culicidae and Stratiomydae, are obliged, in order to breathe, to rise to the surface of the water, where they emerge only the stigmatic orifices, and the air then adheres to the coronets of hairs on the stig mata. Many Tipulidae, such as Ptychoptera, communicate even more easily with the air by means of their long, articulated, siphon-tube; see Swammerdam, Bib. der Nat. Taf. XXXI. fig. 5, Taf. XXXIX. (Culex and Strato-

\(^8\) By this disposition of the stig mata, the larvae of the Dytiscidae, Culicidae and Stratiomydae, are obliged, in order to breathe, to rise to the surface of the water, where they emerge only the stigmatic orifices, and the air then adheres to the coronets of hairs on the stig mata. Many Tipulidae, such as Ptychoptera, communicate even more easily with the air by means of their long, articulated, siphon-tube; see Swammerdam, Bib. der Nat. Taf. XXXI. fig. 5, Taf. XXXIX. (Culex and Stratiomydae); Lycett, Mém. du Mus. XIX. Pl. XVIII. (30) fig. 1-3 (Ptychoptera). The parasitic larvae of the Conopidae, and of Ocyptera of the Tachini race, which live in the cavity of the body of Cassida, Pentatoma, Bomus and Andrena, obtain the necessary air for their respiration by placing the posterior extremity of their body, which has two stig mata, in contact with a stigma or tracheal trunk of the insect in which they live; see L. Dufour, Ann. d. Sc. Nat. X. 1837, p. 255, VII. 1837, p. 16, Pl. I. fig. 13.

\(^9\) See Recammann, loc. cit.

\(^9\) See Lycett, loc. cit. p. 4.
pupae, respire by two stigmata situated on the sides of the cephalothorax.  

Most of the acephalous larvae of Diptera have only four stigmata, of which two are situated on the truncated extremity of the abdomen, and the two others, smaller, upon the sides of the second segment of the body. These last have sometimes a tubular form, and with some species, are even divided digitiformly at their extremity. With the larvae of many Syrphidae and Tachinidae, the two posterior stigmata consist of two siphons, which are often fused into one. The larvae of the Coccidae have only four stigmata situated on the under side of the middle portion of their body. Most of the larvae of the Coleoptera, Hymenoptera, Lepidoptera, as well as the cephalous ones of the Diptera, have numerous stigmata situated on each side in the middle of the segments of the body, and which are never wanting, constantly, except with the second and third thoracic, and the last abdominal segments.

§ 344.

The numerous differences of the trachean system in the various families of the Insecta may be classed under two principal forms.

1. With the first and most common, there are two large lateral trunks upon the sides of which open trunks which arise from the stigmata. From these lateral trunks branch off tracheae to the various parts of the body.

2. With the second form, the trunks which arise from the stigmata or trachean branchiae, directly ramify over the organs, but give off, both forwards and backwards, branches of communication to the neighboring trunks. The branches of one and the same segment frequently interanastomose by transverse trunks.

Often these two forms of tracheae coexist in the same individual. In many cases, the secondary tracheae, in opening into the main trunks, are dilated into a large vesicle, or have upon their course numerous similar vesicles which give the whole system a varicose aspect.

Among the Apidae, the trachean system is of the first form with the Pediculidae, Nirmidae, and Poduridae. But the Lepismidae form an exception in this respect, each of their stigmata opening into a trunk, which, without anastomosing with the neighboring trunks, is isolatedly ramified.

With the Hemiptera, the trachean system presents many modifications. The trunks arising from the stigmata, sometimes ramify without anastomosing, and sometimes open into two lateral trunks. The musical Cicadidae

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10 See my Memoir in Wiegmann's Arch. 1843, I. Taf. VII.
12 The siphon is very long, articulated, and situated at the extremity of the body with the larvae of Eristalis; see Reimart, Mem. loc. cit. IV. Pl. XXX. XXII.
13 See Burmeister, Handb. &c. II. Taf. I. fig. 10-12.
1 See, beside the works of Burmeister and Lachardiere, the work of Marcel de Serres, in the Mem. du Mus. IV. p. 313.
2 With the Poduridae, the six trachean branches given off from the two main trunks, have each an oval dilatation; see Nicolet, loc. cit. p. 47. Pl. IV. fig. 5.
3 Guérin (Ann. d. Sc. Nat. V. 1836, p. 374) thinks that the trachean system is wanting with Machilis; but this must be incorrect, for Burmeister (Ann. 1834, p. 137) has observed this system with Lepisma, with which it had for a long time before been sought in vain. I have very distinctly observed it in Machilis, as well as in Lepisma, and its organization is the same in both. The vesicles which, with Machilis, are situated on the sides of the abdominal appendages, and which Guérin thinks are respiratory organs, must have another function.
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and the Pentatomidae, have varicose tracheae. With Cicada, there are two of these vesicles situated at the base of the abdomen distinguished for their very large size.\(^4\) With Nepa, the primary trunks pass into the two lateral trunks, and form transverse anastomoses which extend from one side of the body to the other. In the thorax, the two lateral trunks form several large vesicles, between which arise, upon the sides, two other trunks which send an infinite number of very fine branches to the thoracic muscles.\(^5\)

With the Diptera, this system is of the first form. It often presents, especially with those having a large and short abdomen, vesicular dilatations of which there are two, situated at the base of the abdomen, very large and distinct, sometimes filling nearly the whole abdominal cavity.\(^6\) It is, moreover, with the larvae of this order, that this form of tracheae is most completely represented. The two lateral trunks are connected by the same number of transverse anastomoses as there are segments of the body.\(^7\)

With the Lepidoptera in all their states, this system is also of the first form.\(^8\) With the imagines of some Sphingidae, Bombycidæ and Noctuidæ, whose flight is continual, there are numerous vesicular dilatations and appendages of the tracheæ.\(^9\)

The tracheæ of the Hymenoptera, which, throughout, are of the first form, send off from their two principal trunks numerous transverse anastomoses, and usually present vesicular dilatations at many points.\(^10\) Of these last, those situated on the abdominal portion of the two trunks are very large, and often contiguous, so that the trunk to which they belong appears like a large sac constricted from point to point.\(^11\) Sometimes there are only two of these vesicles, which are distinguished from the rest by their enormous volume, situated at the base of the abdomen.\(^12\) With the larvae, there are found, pretty commonly, two main trunks connected by transverse communicating tubes.\(^13\)

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\(^4\) See Burmeister, Handb. &c. Taf. II. fig. 10-12 (Coccidae); L. Dufour, Recherch. loc. cit. Pl. XVII. fig. 194 (Tetriga), and Carus, Analekt. &c. p. 156 (Cynipidae).

\(^5\) See L. Dufour, Recherch. &c. p. 234, Pl. XVIII.

\(^6\) With the Muscidae, Syrphidae, Tabanidae, Asilidae, Lepidoptera, &c. For the tracheal system of the larva and pupa of Sarcopega caemarothalasis, see L. Dufour, Mem. présents, &c., IX. p. 572, Pl. II.

\(^7\) Swammerdams, Bib. der Nat. Taf. XL fig. 1 (larva of a Stratiomyi); Boué, Natursch. d. Insek. Taf. VI. fig. 1 (larva of an Anthomyia), and L. Dufour, Ann. d. Sc. Nat. XII. 1839, Pl. I.-III.

\(^8\) Lyenert, Traité, Pl. X. XI. (larva of Cassandra Hymirfera). While the Syrphidae and Muscidae are passing into their pupa-state, the posterior stigmata disappear, the two anterior ones alone remaining active. With the Syrphidae these last often appear as two short tubes inserted on the cervical region.

\(^9\) See Sprengel, loc. cit. Tab. III. fig. 24 (Sphynx Rigistris). Sometimes the number of these appendages is reduced to two large aërial reservoirs situated in the thorax; see Suckow, Anat. physiol. Untersuch. p. 36, Taf. VII. fig. 30 (Gastropacha pilis).

\(^10\) These dilatations are wanting with the Cynipidae, Chalcididae, and some Ichneumonidae. For the tracheal system of the Hymenoptera in general, see L. Dufour, Recherch. sur les Orthopt. p. 574.

\(^11\) With the Apidae, Anthridæ, Vespidæ and Bombycidæ; see Brandt and Rateburg, Mediz. Zool. II. Taf. XXV. fig. 30 (Apis mellifica), and Newport, Philos. Trans. 1836, Pl. XXXVI. or Cyclop. &c. II. fig. 450 (Bombus terrestris).

\(^12\) With many of the Tenthredinidae, with Myrmephyra, Sonita, Crabro, Pompilus, Spheco, &c.

\(^13\) See Strammerdam, Bib. der Nat. Taf. XXIV. fig. 1 (larva of a bee). According to the observations of Rateburg (Die Ichneumon. d. Forstins. p. 63, 81, Taf. IX.), the parasitic larvae of Microgaster and Anomalou are very singular. When young, they have no traces of tracheæ, and respire, perhaps, by means of a caudal appendage enveloped by a thin membrane.

\[^5\ 344, note 10\] See Newport (On the formation and use of the air-sacs and dilated tracheae in Insects, Trans. Linn. Soc. June, 1847); these sacs are formed during the metamorphoses of the insect, and he adopts the view of Hunter, that the vesicles serve chiefly to enable the insect to alter its specific gravity at pleasure during flight, and thus diminish the muscular exertion required during these movements. — Ed.
The true Neuroptera, in all their states, have a pretty simple trachean system provided with two lateral trunks. But with the Orthoptera, on the contrary, this system is usually very complicated. It is, indeed, less so with the Blattidae, Forficulidae, Ephemeriidae, and Perlidae; but with the Libellulidae, the two lateral trunks are very large and arise from the trachean branchiae together with two other trunks. With the other Orthoptera, the tracheae are very numerous and disposed according to the second type or form, their trunks being connected by a multitude of voluminous, longitudinal, and transverse anastomoses, giving the whole a reticulated aspect. With the Acrididae, most of the transverse anastomoses have large air-reservoirs on their course.

With the Coleoptera, the tracheae are always highly developed, and disposed, with the larvae, after the first type, but with the imagines, after the second. With these last, the anastomosing canals, which connect the primary trunks, are often double. With the Palpicornes, and Lamellicornes, this system is most highly developed,—the fine as well as the larger tracheae having a multitude of terminal vesicles.

The Malpighian vessels, which are widely spread among the Insecta in all their conditions, must now, since uric acid has been detected in their secretion, be regarded as Kidneys.

**CHAPTER VIII.**

**ORGANS OF SECRETION.**

**I. Urinary Organs.**

§ 345.

The Malpighian vessels, which are widely spread among the Insecta in all their conditions, must now, since uric acid has been detected in their secretion, be regarded as Kidneys.

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15 Suckum, in Heusinger's Zeitsch. II. Taf. I. II. (larva and imago of an Aeschna).
16 With the Locustidae, Achetaidae and Mantisidae; see L. Dufour, Recherch. sur les Orthopt. &c. p. 239, Pl. I. fig. 1 (Oedipoda), and Marcel de Serres, Mémo. du Mus. IV. p. 291, Pl. IV. (10) (Mantis), also in Isis, 1815, p. 627, Taf. IX.
17 Marcel de Serres, loc. cit. Pl. III. (15) (Trusalis), and L. Dufour, loc. cit. Pl. I. (Oedi-
18 poda).
19 See Burmeister, Trans. Entom. Soc. I. Pl. XXIV. fig. 9 (larva of Calosoma sycophanta), and Audouin, Ann. d. Sc. Nat. IX. 1826, Pl. XXIII. fig. 5 (Lyitta vesicatoria).
19 See L. Dufour, Ann. d. Sc. Nat. VIII. 1826, p. 23, Pl. XXI. bis. fig. 1, and Pietet, Mémo. de Genève, VII. p. 397, fig. 6 (Homoautichorus heros).
20 Sowerwardanum, Bib. der Nat. Taf. XXIX. fig. 9 (Gastrotrapes nasicornis), and Straus, Consid. &c. Pl. VII. (Mesiobonta sulcata). See also, for the Coleoptera in general, L. Dufour, Ann. d. Sc. Nat. VIII. 1826, p. 22.
1 As yet only Coccus, Chermes, and the Aphididae, have been found wanting the Malpighian ves-
21 sels; see Randohr, Verdauungswerk. d. Insect. p. 198, Taf. XXVI. and L. Dufour, Recherch. sur les Hodipt. p. 116, fig. 114. I have been unable to find them with the Strepsiptera in their various stages of development. The male imagines of Xenos Rossii, alone, have presented to me, at the extremity of the digestive canal, a singular glandular appendage resembling a cribiform lobe, and which serves, perhaps, as a urinary organ.
2 For a long time the Malpighian vessels were regarded as biliary organs, when Renger expressed the opinion that they were urinary organs, without, however, having demonstrated the presence of uric acid in their secreted product (Physiol. Untersuch. über die Haushaltung der Insekten. 1817, p. 27). This chemical proof was furnished by BrunoWaller and Wurzer (Mecell's Deutsch. Arch. II. 1816, p. 629, and IV. 1818, p. 215), with Bombyx mori. Subsequently, the existence of this acid has been confirmed by Chevrel with Mesi-
23 obonta vulgaris (Straus, Consid. &c. p. 251), and by Audouin with Leucanus cecus and Poli-
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These always consist of several very long small tubes which, either separately, or by means of one or two common excretory ducts, are inserted upon the posterior or pyloric extremity of the stomach. These ducts are sometimes dilated, bladder-like, at their point of insertion. The opposite extremity of these uriniferous canals either terminates caecally, or passes arcuately into that of another. When, as is usual, they are very long, they embrace the digestive canal with numerous irregular convolutions. With certain species, they creep, by their anterior extremity, between the tunics of the stomach, or by their posterior between those of the colon; this remarkable relation has often led to the opinion that these organs have two outlets into the digestive canal. (6)

These vessels are yellowish or brownish in color, and often slightly variscose. (6) They are composed of an external homogeneous tunic filled internally with cells. These last are very large, and are disposed rather in rows, than adjacently; and nowhere can there be perceived in the interior of the vessels a glandular canal defined by a special epithelium. Each cell contains a clear, colorless nucleus, and a multitude of very fine granules which appear black by direct light, but by reflected light present a dirty-yellow or brown, rarely a green or red, aspect. (6) The granular contents of the cells, which give to these vessels their peculiar color, are scattered, when the cells are ruptured, through the intercellular spaces, and flow gradually into the digestive canal. Thus excreted, they accumulate in the colon or in its caecal appendage, and are evacuated with the faeces, or separately, as a troubled liquid of a color varying according to the species. (6)

§ 346.

The Malpighian vessels present numerous modifications as to their number, their length, their points of insertion, and their modes of grouping, in the different orders of the Insecta. (1)

With the Aptera, they are of median length; with the parasitic species, and with the Lepismidae, they are four in number; and six with the Poduridae. (2)

The Hemiptera have never more than four of these vessels, which are pretty long, whose extremities are looped with the Hydrocorisae and many

3 L. Dufour has clearly demonstrated the usual caecal terminations of these vessels; see Ann. d. Soc. Nat. XIV. 1840, p. 291, Pl. XI. fig. 11 (larva of Mordella), and XIX. 1843, p. 155, Pl. VI. fig. 9 (Hemamullerus herois).

4 The uriniferous canals of Melolontha vulgaris and Spinaxis ligustrei form, in this respect, a remarkable exception. In a great part of their course, they have on each side short caeca, perpendicularly disposed; see Ramdohr, Abhandl. &c. Taf. VIII. fig. 1, 2; L. Dufour, Ann. d. Soc. Nat. III. 1823, Pl. XIV. fig. 4, 5; Straus, Consid. &c. Pl. V. fig. 6, 10 (Melolontha); and Neupert, Cyclop. loc. cit. p. 974, fig. 432 (Spinaxis).

5 For the intimate structure of these vessels, see H. Neevelt, in Maltier's Arch. 1846, p. 41, Taf. II. 6 With the holometabolous Insects, the urine is evacuated isolated, especially when they approach the completion of their pupa-state. It is well known that the Lepidoptera, when bursting from their pupae, emit a considerable quantity of urine, of a variable color. In the larva and pupa of Myrmelicon, it is gradually accumulated to a large quantity of a rose-color, in the digestive tube, and which the perfect insect immediately discharges on leaving the pupa-envelope, as a solid, elongated ovoid body. Réaumur (Mem. VI. 10 mém. Pl. XXXIV. fig. 12, 13) and Roessel (Insecteäulust. Hft. p. 123, Taf. XX. fig. 28, 29) have taken this urinary concretion for the egg of this insect. Sometimes there is precipitated in the urine, red crystals of a quadra-pyramidal form; for example, with the larva of Spinaxis and Ephemeræ.

6 For those modifications in the different orders of Insecta, see the figures belonging to Ramdohr's work (Verdauungswerke, &c.); those of Suckow, in Heusinger's Zoisich. III. and L. Dufour. Sur les vaisseaux biliares ou le foie des Insectes, in the Ann. d. Soc. Nat. XIX. 1843, p. 145, Pl. VII.-IX.

2 See Tyreliomus, Verm. Schrift. II. Taf. III. fig. 1 (Lepisma), Summartadamm, Bib. der Nat. Taf. II. fig. 2 (Pediculus), and Nicolet, loc. cit. Pl. IV. fig. 2 (Podura).
of the Geocoridae. With some species, their excretory ducts form one or two vesicular dilations situated above the colon. It is only with a few Geocoridae, and with the Ciacidae, that the extremities of these canals are free. With this last group, and with the Coccinellidae, they creep with a portion of the intestine, between the tunics of the ante-stomach, before opening into the lower extremity of the true stomach.

With the Diptera, there are four long uriniferous vessels. The Culicidae and Psychodidae, alone, by exception, have five. With very many species, these canals are united in twos, and open, by a common excretory duct, into the lower extremity of the stomach. Loop-like anastomoses occur only with the Tipulidae, Leptidae, and Bombylidæ.

With the Lepidoptera, there are nearly always six long, free, uriniferous tubes, which open into the stomach by two excretory ducts.

The Hymenoptera are distinguished for their considerable number of these vessels, which are usually short and surround the pylorus in numbers of twenty to one hundred and fifty. With the Orthoptera, these vessels are inserted in a similar manner, but are often much more numerous.

The Termitidæ, alone, form an exception,—having only six.

The true Neuroptera are distinguished from the Orthoptera in that their vessels of this nature are long, flexuous, and only six to eight in number.

With the Coleoptera, they are usually long, make numerous convolutions, and never exceed four or six in number. When four, they are nearly always joined by twos at their extremity; and when six, they are often attached by their extremities to the colon.

The urinary vessels of the larvae and pupae resemble somewhat those of the perfect Insecta. With the larvae of certain Hymenoptera, and Orthoptera,
alone, their number is smaller, and with those of the Lepidoptera, the extremities of the six tubes of this kind are insinuated between the tunics of the colon; while, with the imagines they are free. With the Buprestidae, the larvae have six, but the imagines only four, of these vessels.

II. Organs of Peculiar Secretions.

§ 347.

A great number of the Insecta, in both their larval and their perfect state, have glandular organs which secrete very varied products remarkable for their specific properties.

Many species have a secretory apparatus analogous to the cutaneous glands of the Vertebrata, which have received the name of Glandulae odoriferae. These consist of round follicles situated under the skin, whose very short excretory ducts open between the segments of the body, or between the articulations of its extremities. Their product emits a powerful odor, and, with some species, is evacuated in the form of droplets, or, with others, covers the whole surface of the body, being perceived only by its odor. The disagreeable odor emitted by the Bugs is due to a fluid secreted by a single, yellow, or red pyriform gland, situated in the centre of the metathorax, and opening between the posterior legs.

With other Insecta, there are analogous secretory organs, concealed in the posterior extremity of the abdomen, which copiously emit a fetid, troubled liquid, through an orifice situated by the side of the anus. These Anal Glands are usually double, and consist of simple follicles whose secretory product accumulates in round, or oblong contractile reservoirs. With many

[larva of various Lomellinere;] and Buremeister, Trans. of the Entom. Soc. I. Pl. XXIV. fig. 10 (larva of a Calosoma), and his Abhilarz. z. Naturgeschichtl. d. Calandra, loc. cit. fig. 3.

The larvae of the Apidae and Vespidae have only four orifices vessels; see Swammerdamm, Bib. der Nat. Taf. XXIV. fig. 6 (larva of a bee); Suckow, in Hesseing's Zoisch. Ill. Taf. VI. fig. 180, and Randolhr, loc. cit. Taf. XII. (larva of a Vespa); finally, Ratkell, in Müller's Arch. 1844, p. 56, Taf. H. (larva of a Gryllotalpa).


2 See L. Desfour, Ann. d. Sc. Nat. XIV. 1849, p. 114. Lew. (Istot. Zool. 1841, p. 37, fig. 2) did not, probably, observe these canals in the larva of Buprestis mariana; for, otherwise, he would not have regarded as such the two caecal appendages at the upper extremity of the stomach, and which the Buprestidae have also in their imago-state (see § 328).

1 With Eugrepin, and Zygnaema, a fluid of this kind, yellowish, transparent, exudes under the collar; and with many Meloidae, Chrysomelidae, and Coccinellidae, it escapes from the knee-joints. The larvae of these last Coleoptera, as well as those of many Tenthredinidae, emit droplets of fluid from the surface of their skin from the heat touch. Very often the odor of this fluid reminds one of fresh poppy juice. The fluid emitted from the ophidio-predatorian articulation, with Cyniabes and Dytiscus, has a very nauseating order. I am unable to decide whether or not the transparent liquid which escapes with various Aphididae through two tubes on their abdomen, belongs to this same category of secretions.

2 Certain Phryganeidae, Homera, Chabroniæ, Scelidae, Scirtidae, &c., emit specific odors without the secretion of their Glandulae odoriferae being visible.

3 See L. Desfour, Recherch. loc. cit. p. 256, Pl. XVII. fig. 104. Moreover, the opinion that all the Bugs emit a bad odor is incorrect; for with many, as for example Syromastes, the Glandulae odoriferae exhale a very agreeable odor resembling that of a fine bergamot pear.

4 These anal glands, which Buremeister (Handb. L. p. 157), Grand (Outlines, &c., loc. cit. p. 554) and other anatomists have mistaken for urinary organs, consist, with the Dytiscidae and Gyrinidae, of two simple, long, and flexuous canes, whose reservoirs, having two short excretory ducts situated
Coleoptera, these anal glands secrete a caustic fluid which has a penetrating and more or less aromatic odor. They are somewhat ramified, or composed of vesicles disposed botryoidally, and open into one or several long, excretory ducts. These last open into two pyriform, muscular reservoirs, whose powerful contractions expel, as a means of defence, the secreted fluid. The Formicidae, also, have, in the anal region, a glandular apparatus from which they eject a caustic, acid fluid. This apparatus is single and composed of one reservoir whose neck opens into a simple tube. The larvae of Harpyia, also, defend themselves by ejecting an irritating liquid secreted by a glandular sac, which opens directly back of the head on the under surface of the first segment of the body.

Among the Hymenoptera, the females of the Vespidae, Fossorae, Andrenidae, and Apidae, have, in the anal region, a glandular apparatus which secretes a poisonous fluid introduced by means of a hollow sting into the tissues of their prey or enemies. This Poison-apparatus is composed of two long tubes which are sometimes very ramose. The intimate structure of these tubes resembles that of the salivary glands. The two poison-glands are sometimes isolated, sometimes united into a common canal, and their product is poured into a pyriform reservoir, which has thin but contractile walls, whose longer or shorter excretory duct opens into the sting. This sting is formed by the intimate union of two lateral pieces, and plays in a eleft horny sheath. Often, its extremity is covered with backwardly-pointing denticles. Both the sheath and the sting have, at their base, a peculiar muscular apparatus by which they are protruded and withdrawn.

near the arms, glaucinate a highly stinking liquid. With the Silphidae, where this apparatus is single, the reservoir opens laterally into the rectum; see H. Muckel, in Muller's Arch. 1846, p. 47, and L. Dufour, Ann. d. Sc. Nat. VIII. 1826, p. 15, III. Pl. X. fig. 3, 4, 5, Pl. XIII. fig. 5, 7 (Opticus, Gyrinus and Silpha). With Gryllotalpa, the anal glands consist of small lobular bodies inserted on the reservoir which receives their product; see L. Dufour, Recherch. sur les Orthopt., &c., p. 346, Pl. II. fig. 19.

With the Carabidae, and Staphylinidae; see L. Dufour, Ann. d. Sc. Nat. VIII. 1826, p. 6; II. Pl. XX.-XXI.; III. Pl. X.; and VII. Pl. XIX.-XX.; J. Muller, De Glandul. Struct. &c. Tab. I. fig. 17-18; and Stein, Vergl. Anat. u. Physiol. d. Insek. 1847, Tab. I. fig. 4, 5, 6 (Diamox) and Tab. III. fig. 3, 1. u. (Oxytates).

With Brachinus, as is well known, this product is so volatile as to immediately become gaseous on its ejection.

With the Bess, which have a poison-apparatus of this kind, ought to be regarded as females whose genital organs are undeveloped. Many fœtuses of Hymenoptera, which feed their young with insects, wound these last with their sting, that they may be mastered, and conveyed the more easily to the nest. Indeed, some carry their prey into their nests transixed with the sting. (See my Obscr. quod. de Oxycelo atque Miligrammam, 1841, p. XI.) The wound does not always kill the insect, but simply disables it, so that they remain fresh for several days by the side of the larvae for whose food they are to serve.

There are two simple tubes with Vespa, Scelis, Crabro, Halictus, Apis, &c.; but they are ramified with Pompilus, Philanthus, Larva, Bombus, &c.

With the Hymenoptera, the females of the Vespidae, Fossorae, Andrenidae, and Apidae, have, in the anal region, a glandular apparatus which secretes a poisonous fluid introduced by means of a hollow sting into the tissues of their prey or enemies. This Poison-apparatus is composed of two long tubes which are sometimes very ramose. The intimate structure of these tubes resembles that of the salivary glands. The two poison-glands are sometimes isolated, sometimes united into a common canal, and their product is poured into a pyriform reservoir, which has thin but contractile walls, whose longer or shorter excretory duct opens into the sting. This sting is formed by the intimate union of two lateral pieces, and plays in a eleft horny sheath. Often, its extremity is covered with backwardly-pointing denticles. Both the sheath and the sting have, at their base, a peculiar muscular apparatus by which they are protruded and withdrawn.

**Note 1:** For the peculiar glandular apparatus for this purpose, with Brachinus, see Karsten, in Muller's Arch. 1845, p. 367. Contrary to other Entomologists, this observer regards this apparatus as of a urinary nature, for he states that an analysis of its secretion furnishes a product analogous to urea. — Ed.

**Note 2:** For the poison-apparatus in the Hymenoptera has been investigated by Will (Schecken and Froriep's Nat. 1845, Sept. p. 17) who found, with Ants, Bees, and Wasps, that this product consisted of formic acid and a whitish, fatty, sharp residuum, the former being the poisonous substance. — Ed.
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There is another category of secretory organs which, with many females, open at the base of the ovipositor, but as they are intimately connected with the act of oviposition, they will be most properly described with the genital organs. (13)

A very large majority of the holometabolic Insecta have, in their larval-state, silk-organs, the secretion of which they use, some, to weave a cocoon when about to pass into the pupa-state, or to close a hollow refuge they have sought; others to fasten together foreign bodies for the fabrication of their retreat. These organs are, therefore, most developed at the period when these insects approach their pupa-state; but with the larvae of the Psychidae, Tortricidae, and Lasiocampidae, they are already active during the first epochs of life. The silk-secreting portion of this glandular apparatus consists of two long, somewhat flexuous, thick-walled caecum, situated on the sides of the body, and continuous, in front, into two small excretory ducts, whose common orifice is on the under lip, and usually at the extremity of a short tubular protuberance. (14) With the larvae of Myrmeleon, the silk-apparatus is very remarkable, for the rectum itself is changed into a large sac and secretes this substance, which escapes through an articulated spinneret projecting from the opening of the anus. (15)

With the Apidae, there is a remarkable Wax-secreting apparatus. This wax is elaborated by the Workers under the form of thin discs, which are formed between the imbricated posterior legs, without there having been discovered, as yet, in this region, the orifices of any special glands. It must therefore be supposed that it is produced by an exudation from the thin membranes which connect the different parts of the legs. (16) Moreover, many other Insecta have secretory products which transude through the skin without the existence of any special glandular apparatus, and which are hardened by the air like wax. These products are usually whitish, pulverulent, filamentous, or flocculent substances, which catch upon the surfaces of bodies. (17)

13 See § 350.
14 See Roestel, Insektenbuscht. III. Class. I. Papilio. Acta natururum. Taf. IX. (Bam窒e): Lepanet, Traité, etc., p. 498, Pl. XIV. XV. (Cossus); Suckow, Anat. u. phys. Untersuch. p. 29, Taf. VII. fig. 51 (Gastropacha); Piclet, Recherche pour servir à l'Hist. d. Phryganiens, Pl. III. fig. 1 (Phryganea). The decrease of these organs during the pupa-state has been very carefully detailed by Herold, Entwickelungsgesch. d. Schmetterl., Taf. III., and by Suckow, loc. cit. Taf. II. (Pontia, Gastropacha).
15 See Risamur, Mem. &c. VI. Pl. XXXII. fig. 7, 8; Ramdohr, Abhandl. &c. Taf. XVII. fig. 1.
16 For the intimate structure of the wax-secret ing portions of the skin with the workers of bees, see Treviranus, Zeitsch. f. Physiol. III. p. 62, 225; and Brandt and Ratzeburg, II. p. 179, Taf. XXV. fig. 18. The production of wax with bees has lately been the subject of much research among French naturalists. Mlle Edwards has advocated the opinion before rejected by him, that this substance is secreted by special glands. But L. Dufour, after carefully-made researches, failed to discover them. See the various memoirs on this question in the Compt. Rend. XVIII. and in the Institut. 1843, also in ForrieP's neue Nat. XXVII. XXIX.
17 It is, moreover, easy to be convinced of the absence of these glands with the bee-workers; but if certain Andrenidae are examined, there will be found, on each side of their posterior tibiae, a small pyriform follicle with an excretory duct, and which secretes an oily substance.
18 These cutaneous secretions are observed with various Coccidae and Aphididae, whose entire bodies they cover with a powdery or woolly substance. With the females of Dortheia, not only the entire body is covered with a substance which forms a solid white crust, but also the eggs after their deposition are invested with a similar envelope and thereby glued to the abdomen of the mother. With many male Coccidae, this secretion forms, at the posterior extremity of the abdomen, a bundle of very diverging, long, white and perishable hairs. With some Cicalidae (Lustra and Flota), the thorax and abdomen are covered, in places, by a kind of mould of a similar origin. The larvae of many Tenthredinidae (for example, Tenthredo ovata), as well as those of certain Coccinellidae (Scymnus), exude a liquid which, upon drying, forms white floccula.
CHAPTER IX.

ORGANS OF GENERATION.

§ 348.

The Insecta always multiply by means of genital organs situated in different individuals, and, invariably, are provided with copulatory organs. With certain species, namely, with the Apidae, and Termitidae, the females various Insecta, among which were Dorthesia, Macrodactylus, &c. The wax consists of fibres which are perpendicular to the secretory surface, and is a true product of the integument independent of any special glandular apparatus. — En.


are much less numerous than the males. In the colonies of Bees, Termites, and Ants, there are, beside the males and females, a multitude of neuter individuals known as the Workers or Soldiers.

The sexual parts of insects are developed chiefly during the pupa-state; but their rudiments exist already in the youngest larvae, with which the sexes may then be distinguished.†

The female genital organs persist in a rudimentary germ-like condition with many larvae of Bees, probably owing to the influence of nourishment, for by increasing that of the workers these last may be raised to the rank of females or Queens.⊕

The Aphididae are very remarkable in that they produce, for several successive generations, only females which, in their, turn reproduce, but viviparously and without the direct influence of the males.⊥

The genital organs of the Insecta are composed in general, of two symmetrical Ovaries, or Testicles, situated in the abdominal cavity, and of two ovicasts, or Deferent canals (Tubae, or Vasa deferentia) which unite in a common excretory duct (Vagina, or Ductus ejaculatorius) opening back of

² Herold (Entwicklungs gesch. d. Schmetterl.) has made very interesting researches on this premature development of the genital organs with Pontia brassicae, and which, accord with the obser-
vations of Suckow (Anat. n. physiol. Untersuch. p. 31, Tab. III. V.): on those of Gastracopa pini. Rev. also, Herzl, Integrist. de Animal. Vert. cur-ent, in ovo format. Tab. I. fig. 9, or Ann. d. Sc. Nat. XII. 1839, p. 186. Pl. VII. fig. 8. To be convinced that in the other orders of Insecta the genital organs are also developed at a very early period, it is only necessary to cast a glance over the figures which Suckow (Heusinger's Zeitsch. II. Tab. X. fig. 9) has given of Aphrophora spec-

³ For the origin of the neuters with the Hymen-
optera, see Treitschus, Zeitsch. f. Physiol. III. p. 220. In all the bee-workers there are found vestiges of the ovaries and of the seminal receptacle. See Ratzeburg, Nov. Act. Nat. Cur. XV. part II. p. 615, Tab. XLVII. and my observations in Ger-
mar's Zeitsch. IV. p. 315. 

² This mode of generation of the Aphididae (see § 356) quickly reminds one of that which Steen-
strap has called Alternate Generation. Certain species of Cynips belong probably to the same cat-
egory, for their males have yet been undiscovered. Hurtig (Germar's Zeitsch. IV. p. 309) has been unable to find any individuals of this sex among thousands of Cynips fallii and disina. Similar observations have been made by L. Dufour (Re-
cerch. sur les Orthop. &c. p. 827). It is to me probable, also, that the capacity which many ento-

mologists attribute to Psyche of laying eggs with-
out a previous copulation is an example of alternate generation.*

* [§ 345, note 4.] The peculiar economical re-
tations of certain Hymenoptera (Cynips) referred to above have received some explanation by the researches of Frauen dorf (Hardinge Berichte üb. d. Mitchell. v. Focoule d. Naturwiss. in Wien. IV. p. 247, or Wiegmann's Arch. 1840, Th. II. p. 115), upon Gastracopa tanestris. He gathered two nests of the larvae at the end of June, 1836; by the middle of August the caterpillars had spun up, and on Sept. 18, the first imago appeared, and the second on Dec. 14; both of these were males; in the spring of 1837, some twenty individuals of both sexes appeared; others, likewise, in the autumn of 1837; others still in the following year, and the last of them on the 4th of March, 1842. The pupa-
state of the last of the brood was therefore five and a half years, while that of the first was only as many weeks.

In regard to the alleged anomalous reproductive relations of Psyche, they have received the special attention of Siebold, who has quite cleared up the subject (Uebor der Fortpflanzung von Psyche: Ein Beitrag z. Naturgeschichte der Schmetterlinge, in Siebold und Küklicher's Zeitsch. I. 1848, p. 93; also in his Bericht üb. die entomol. Arbeiten d. aeh. Gesellschaft. im J. 1850, or its transl. in the Transact. of the Entom. Soc. London, 1. 1851, p. 234. In the first of these researches made upon the genera Psyche and Fumes, there was no evidence that, with the individuals of these genera, reproduction occurs in an anomalous manner, that is, without the aid of the male; on the other hand, the facts of the well-developed character of the inten-

ginal organs of the females, and of the capacity of the male to impregnate the female while she is concealed deeply in her case—these preceded the hypothesis of Lestina sine concabili. But sub-
sequent researches made upon Talaeporia have shown him that, with the individuals of this genus, non-sexual reproduction does occur, presenting simi-
lar phenomena and conditions as the generation of the viviparous Aphides. It is proper to remark, how-
ever, that the carefully-made researches and experi-
ments of Speyer upon the genital organs and mode of reproduction of Talaeporia liehenella, several years before, had shown that two successive generations here occur without the presence of males; see his paper in the Entom. Zeit. 1847, p. 18. For the phenomena and their interpretation of the development of the viviparous Aphididae, see my note at § 355, end.—Eu.
the anus. This duct has several double or single appendages, of which one with the females serves as a seminal receptacle (Receptaculum seminis), or as a copulatory organ (Bursa copulatrix), while the others, in both sexes, are true secretory organs. The vagina is often prolonged into a horny ovipositor, and this same organ modified, with the males, is the Penis.

The Eggs of Insecta are very varied in their forms and colors. Externally, they are frequently marked by prominences and raised lines, forming a very varied, and often a very elegant design.\(^5\) Those of some Cynipidae, Ichneumonidae, and Siricidae, have one of their ends prolonged into a long, straight or curved thread.\(^6\) With some Hydrocorisae they are oblong and their posterior extremity is covered with long, stiff bristles.\(^7\) They have, usually, a very solid chorion, and a thin vitelline membrane. The vitellus is composed of fat-vesicles more or less colored, which communicate their color to the entire egg. The germinative vesicle contains a germinative dot which is often composed of several parts.\(^8\)

These eggs are formed after two different types.

1. With the Orthoptera, and various Coleoptera, the germinative vesicle is formed in the posterior extremity of the tubular ovaries, and is gradually surrounded by a mass of granular vitelline substance. This vitelline mass continues to increase until, at last, there is formed on its surface a chorion, at first soft, but which finally becomes solid. During the course of this development, the eggs succeed each other in a row, and in this way advance towards the opening of the ovarian tube.\(^9\)

2. With the Lepidoptera, Diptera, Hymenoptera, Neuroptera, Cecindelidae, Carabidae, and Hydrocanthari, the mode of formation is wholly different. The vitelline mass which is disposed around the germinative vesicle, increases in the following manner: Between each two vitelline masses, there appear a group of large vitelline cells whose contents are blended with the subjacent vitelline mass; while, the chorion is developed from a layer of vitelline cells, commencing by its inner portion. It gradually extends over the vitelline mass and cells, and finally, when the vitellus has reached a certain volume, closes at the upper portion of this last. The epoch at which the eggs reach their maturity coincides, with the Lepidoptera, Tipulidae, and Ephemeridae, with the end of their pupa state, so that these insects are able to deposit their eggs as soon as they have cast off their pupa envelope; while, with the Libellulidae, the Laccustidae, and especially the Apidae, the eggs are not matured in the ovaries until a long time after.\(^10\)

With all Insecta, the sperm contains very active filiform spermatid particles which become immediately stiff and looped when put in water. These particles are developed in large cells whose involucrum finally dis...
appears, while the spermatic particles thus formed remain together for some time and finally are united in fasciculi of variable forms.\(^{11}\)

With many species, these bundles are disposed one after another, and then united forming long, vermicular bodies.\(^{12}\) Only gradually, as the sperm mass passes along the deferent canals, are the spermatic particles separated to unite again under new and remarkable forms. These last consist of long, penniform bodies, having very singular movements, for their free extremities oscillate to and fro without cessation.\(^{13}\) A kind of spermatophore is also observed in the female organs of many species belonging to the Lepidoptera, Orthoptera and Coleoptera. It consists of a peculiar hollow body, usually somewhat pedunculate, with pretty solid albumen-like walls, and filled with spermatic particles.\(^{14}\)

### I. Female Genital Organs.

§ 349.

The two Ovaries are always composed of a larger or smaller number of tubes, whose free extremities are extremely small, but which gradually increase in size to their point of insertion on the oviducts. From their caecal terminations is prolonged a delicate thread, which, bound together with the others, serves to attach the two ovaries to the thorax.\(^{15}\)

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\(^{11}\) For the spermatic particles of the Insecta and their development, see my memoir in Müller’s Arch. 1836, p. 50; and Kolliker, in the Neue schweiz. Denkschrift, VII. p. 24.*

\(^{12}\) See my memoir in Müller’s Arch. loc. cit. p. 38, Taf. III, fig. 16-18 (Ponidia). These verniform bundles are observed not only with all the Lepidoptera, but also with certain Diptera and Coleoptera; see Loom, Horae anatom. Htt. 1, 1841, p. 26, Taf. H. (Scatopae), and Hammerschmidt, Isis, 1839, p. 535, Taf. IV. (Cleanus and various Lepidoptera). This last mentioned naturalist has, however, taken these cords for gigantic spermatic particles, to which he has given the name of Pagius, Spiritura and Cincinnaur.

\(^{13}\) I have discovered these penniform bodies composed of spermatic particles in the Receptaculum seminis of Locusta and Decticus; see Nov. Act. Nat. Cur. XLI. 1835, p. 251, Tab. XIV. Dujardin (Observ. au Microscope, 1842, Pl. XI. fig. 18, 19) had already perceived similar bodies in the male organs of Tetrigonni pulejea and Spho- drus terricola. Stein (Vergl. Anat. loc. p. 144, Taf. I. fig. 19 (Loricaria)) has also found them in the seminal receptacles of the females of various Carabidae.

\(^{14}\) Pyriform, short-pedunculated spermatophores are found in the Receptaculum seminis of the

\[^{15}\] [§ 343, note 11.] The spermatic particles of the Insecta are described above, as well also by Wagner and Leuckart (loc. cit. Cyclop. Anat. and Phys.), as being invariably filiform. This is incorrect: it is true they are generally so; as, for instance, with all the Coleoptera, Lepidoptera, Diptera, Apidae, Hymenoptera; but with some families of the other orders (the Hymenoptera, Neuroptera and Orthoptera) their form is quite different, and I am only surprised that it has not been before noticed. Thus, with the Libellulidae, Ephemerid-
ovarian tubes are, moreover, always enveloped by numerous tracheal networks. Upon their length, which is very variable, depends the number of the eggs or germs which are disposed in a single file; and in this way, they may be distinguished as uni-, bi- and multi-locular. The two Oviducts are usually short and often dilated into a kind of calyx at their upper extremity, if there are numerous ovarian tubes meeting at this point.

The Seminal receptacle (Receptaculum seminis) is a double or single, solid capsule (Capsula seminalis) of variable form and surrounded by a muscular layer. It opens into the vagina below the point of junction of the two oviducts, by means of a canal of variable length (Ductus seminalis). This duct has sometimes a simple, or a bifurcated appendage (Glandula appendicularis). The seminal receptacle never contains spermatic particles with those females which have not rejected their pupa covering, or especially with those still in a virgin state; but after copulation it always contains a multitude of these particles moving very actively, and these movements are kept up for a long period, as may be observed with those females which live over the winter.

The Copulatory pouch (Bursa copulatrix) consists nearly always, of a spacious, pyriform reservoir, which, with only a few exceptions, opens into the vagina below the seminal receptacle. During copulation, it receives the penis, and often, also, the sperm which enters either by portions contained in the spermatophores, or enveloped by a shapeless gelatinous substance.

The secretory organs situated at the lower end of the vagina, consist, usually, of two rather long, glandular tubes on each side of the vagina, into which they open, either directly, or through two small special excretory ducts. They often have, on their course, two vesiculiform reservoirs. In most cases, these glandular organs appear to form a Sebacous or

and scattered through the cavity of the body between the faeces. The females are apodous, and the ventral surface of their body, which resembles that of the larva, is occupied by a shallow canal (lateral canal) which terminates casually in the penultimate segment of the body, and opens upon the cephalothorax by a terminal orifice (Genital opening). From this canal pass off into the visceral cavity three to five forward-bent tubes. The eggs are developed in the visceral cavity, and by these tubes the young larvae make their exit therefrom; see my Veter. nat. Naturgesch. d. Wir- bell. Thiere, p. 75, Taf. III. fig. 62, 63; and Wieg- man's Arch. 1848, I. p. 117. Formerly, I erred in taking the ventral for the dorsal surface with these insects.

2 J. Muller has taken these filaments for vessels communicating between the ovaries and the dorsal vessel; see Nov. Act. Nat. Cub. XII. p. 389. 3 For a long time this Receptaculum seminis remained wholly unobserved, or was taken for a Bursa copulatrix, or an organ secreting a viscous substance for gluing the eggs together and to foreign objects. The older descriptions and figures give, therefore, only an imperfect idea. It is only lately that the constant presence and true nature of this organ have been recognized (see my memoir in Muller's Arch. 1837, p. 392, and Stein, Vergl. Anat. Ac. 1847, p. 90). Yet, at this day, the copulatory pouch and seminal receptacle are frequently confounded together; and L. Defour, in particular, persists in his old error in designating this seminal receptacle as a Glutina sphinct.

4 See my observations made upon Vespa (Wieg- man's Arch. 1839, I. p. 107) and Culier (Ger-
Mucous apparatus (Glandulae sebaceae or colleteriae), for they secrete a viscous, coagulable substance, which serves to envelop and glue the eggs together, and to fix them to foreign bodies. With the females of the Ichneumonidae, this apparatus secretes a kind of cement with which these insects close the wounds they have made in the bodies of the Insecta in which they have deposited their eggs. It is probable, also, that, with those Insecta which deposit their eggs by means of an ovipositor in the tissues of plants, thereby producing galls, these same organs serve as a kind of Poison-apparatus causing this diseased formation of the vegetable parenchyma.

§ 350.

The different parts of the female genital apparatus present, in the various orders and families, countless modifications as to number, form and disposition. The most important of these are the following:

With the Aptera, the two ovaries consist each of only four to five tubes, which, with the Pediculidae, open, all, at the top of the corresponding oviduct; while with the Lepismidae, they are separately inserted on the side of the moderately long oviduct. In both of these families, there are two short varicose caeca, which enter laterally the lower end of the vagina, and are probably sebacous or viscous organs. (3) There appears to be here no seminal receptacle or copulatory pouch.

With the Hemiptera, the ovaries consist of four to eight tubes of variable length, disposed verticillate at the extremity of the short oviducts. The Psyllidae and Cicadidae, alone, form an exception in this respect. With the first, the ovaries are composed of ten to thirty unilocular tubes, and with the second, twenty to seventy bilocular ones. These last, moreover, are distinguished by their oviducts being divided into several branches, on the extremity of each of which is a tuft of ovarian tubes. (3) Their Receptaculum seminis consists of two small caeca. (3) The other Hemiptera have only a single seminal receptacle, which is pyriform with the Psyllidae and oviparous Aphididae; (3) is a long, slightly flexuous caecum with the Nancoridae, and Nepidae; and a very long, somewhat flexuous caecum with the Hydrometridae. With many Capsidae, and other Geocorisae, also, it is a pretty long and flexuous caecum, while, with the Pentatomidae, the rather short Ductus seminalis terminates in a brownish, horny, pyriform Capsula seminalis, the constriction and protuberances of which often present a peculiar appearance. Sometimes this tube is dilated into a second vesicle, at whose base is a horny tube containing a second tube which is a direct prolongation of the Capsula seminis. (3) Most Hemiptera have no copulatory pouch,—the Cicadidae, alone, having one which consists of a narrow-necked, pyriform vesicle. (6) With the oviparous Aphididae,

1. See Summardamn, Bibl. der Nat. p. 57, Taf. 11. fig. 8 (Pediculus), and Treichanus, Verh. Schrif. II. p. 15, Taf. 11. fig. 8, 9 (Lepisma).
3. See Merckel, Beitr. k. i. Hefte 1. Tab. I. fig. 6, i; i. L. Dafour, Ann. d. Sc. Nat. V. 1825, Pl. IV. fig. 5, i. i., and fig. 8, d, d; and Doyère, Bull. VII. 1827, Pl. VIII. fig. 3-7, i. i. (Lepad and Cicala).
4. See my memoir on the internal genital organs of the oviparous and viriparous Aphididae, in Forster's neue Nat. XII. p. 380.
5. For the seminal receptacle of the Pentatomidae, see L. Dafour, Recherches, k. i. Sc. cit. Pl. XIV.—XVII., and Siebold, in Müller's Archiv. 1857, p. 410, Taf. XX. fig. 4-6.
6. See Merckel and L. Dafour, loc. cit. According to Doyère (loc. cit. p. 205; Pl. VIII. fig. 3), there is, with the female Cicadidae, a special orifice by the side of the oviduct, which is continuous with the ovipositor, and through which the penis protrudes into the copulatory pouch.

[* [§ 350, note 5] For the female organs of Heteroptera, see Leidy, loc. cit. p. 61. — Ed.]
and many Geoceridae, the secretory apparatus consists of two round glandular sacs,\(^7\) while, with the Cicadidae, it is a single, long flexuous tube.\(^8\) The viviparous Aphididae differ from those which are oviparous, in that their eight ovarian tubes are multicellular, and their oviducts entirely without appendages; while with the second or oviparous, these eight tubes are unicellular, and there is a seminal receptacle and two sebaceous glands.\(^9\)

With the Diptera,\(^10\) the ovaries consist, usually, of numerous short, three or four chambered tubes. With only a few species, these tubes are long and have eighteen to twenty chambers.\(^11\) The disposition of these tubes varies considerably. With some, they are simply terminal to the short oviduct; while with others they form one or more series on the sides of these organs, which, then, are longer.

The Receptaculum semiinis presents the most varied forms,\(^12\) it is usually, triple, rarely simple or double,\(^13\) and is lined with a horny, brown substance. It has a round, pyriform, or oblong shape, and, in this last case, is often flexuous or spiral. The seminal ducts, which lead from the receptacles to the vagina, are sometimes isolated, and sometimes united into one or two common ducts before entering the vagina. Directly below them on each side, are the points of junction of the two secretory organs, which, always present with the Diptera, consist of two simple, rarely ramose tubes, whose very small excretory ducts have, exceptionally only, a vesiculiform dilatation.\(^14\) The Bursa copulatrix appears to be wanting with all the Diptera. But, with many Muscidae, the vagina has, as a seminal receptacle or uterus, a spacious, and sometimes two-lobed reservoir in which the fertilised eggs are accumulated in great numbers, and remain until the larvae are sufficiently developed to be hatched, making these animals viviparous.\(^15\) With certain species of Tachina, this uterus presents a remarkable form; the vagina is very long, spiral, and of equal size throughout; and, at certain periods, is crowded with larvae or small eggs.\(^16\) With the pupiparous Hippoboscidae, the female organs are formed on an entirely special type, corresponding with the remarkable mode of the reproduction

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\(^7\) See L. Dufour, Recherch. loc. cit. Pl. XIV. XIV.
\(^8\) See Meckel, Schuck, L. Dufour, Dogière, loc. cit.
\(^9\) See my researches in Fromeyer's neue Notiz, XII. p. 367. Butrochet (Ann. d. Sci. Nat. XXX. 1853, p. 204, Pl. XVII, C. fig. 1), it would appear, has unwittingly figured the genital organs of an oviparous Aphida, by taking the seminal receptacle for a sperm-receiving organ. In this way he was led to regard the viviparous Aphididae as hermaphrodites.
\(^11\) Epilachra and Tachina; see Locow. loc. cit. Tab. IV. fig. 3, 10.
\(^12\) For the Receptaculum semiinis of the Diptera, see Stobold, in Walter's Arch. 1855, p. 414, Tab. XX. fig. 7-103, and especially Locow, loc. cit. p. 89, Tab. XX.-IV.-V.-IV., and in Geismar's Zeitsh. 111. p. 268, Tab. III.; the Numerous figures of this author will give some idea of the inexhaustible variety of forms of these organs. When L. Dufour (Ann. d. Sci. Nat. I. 1844, p. 262) would regard the seminal receptacle as a reservoir of the neighboring secretory organs, it is evident that this distinguished entomologist must have entirely omitted a microscopic analysis of the substances found in the various glands and other organs of Insecta.
\(^13\) The Receptaculum semiinis is simple with Pulex, Eumes, Dolichopoda, and Hilara; and double with Phipphi, Stomoxys and Tabanus.
\(^14\) See Stobold, and Locow. loc. cit. These glandular appendages secrete with certain Tipulidae a considerable quantity of gelatinous substance which envelops the eggs and binds them in a kind of calcar. These calcar, which are deposited in the water, have for a long time been figured by botanists among the algae under the name of Glororuma.
\(^15\) There are viviparous species in the genera Musca, Anthomyia, Saraphago, Tachina, Dezia, Mitotomerna, &c.; see my memoir in Fromeyer's neue Notiz, III. p. 357, and in Wiegman's Arch. 1855, p. 107; also my Observat. quoad. Faunum. &c. 1854. L. Dufour (Ann. d. Sci. Nat. I. 1844, p. 261) has designated this reservoir as Reservoir ovopturare; see also his Metamorph. d. l'Amat. d. la Phylptia pectinata. Ibid. p. 882, Pl. XVI. fig. 16, g. Locow (Horse anatom. Tab. IV. fig. 3, 11, 14, Tab. V. fig. 13) has figured analogous uterine reservoirs with Musca, Dezia, Phylptia and Euxia.
\(^16\) This long spiral-form vagina, which was formerly described as an ovaemum spirale, is found in Tachina fera, tessellata, grossa, vulpina, haemorrhoidalis, &c.; see my memoir in Wiegman's Arch. loc. cit. p. 104, and Bittinger, Mem. IV. 10 méém. p. 412, Pl. XXIX. fig. 7, 8.
of these animals. The two ovaries are unilocular pouches of unequal size, inserted laterally, by means of a short oviduct, upon the vagina. The upper extremity of this vagina contains sperm, after copulation, and may, therefore, be regarded as a Receptaculum seminis; while the lower portion is widely dilated, and may, therefore, be considered as an uterus. The upper or narrower portion of the vagina receives two small, simple, or somewhat ramose glandular tubes (Glandulæse sebaceæ).\(^{16}\) Below these glands are situated the two excretory ducts of a double glandular apparatus, very voluminous and multiramose, whose product serves, without doubt, to nourish the larvae which are provisionally developed in the uterus.\(^{20}\)

With the Lepidoptera, each ovary is composed of four very long, spiral, multilocular tubes. The Receptaculum seminis\(^{17}\) is pyriform, and often has a long, spiral Ductus seminalis.\(^{20}\) At its base opens a simple or bifurcated accessory gland, and underneath it there is always a large, double, sebaceous gland, consisting of two rather long, flexuous, simple cæca. These last open into the vagina, by means of a short common excretory duct, and each, at their point of union, is usually dilated into a vesiculiform reservoir.\(^{21}\) Some Lepidoptera have, moreover, two smaller ramose glands, situated near the orifice of the vagina, which secrete, perhaps, an odorous substance that excites the copulatory act.\(^{22}\) The copulatory pouch, finally, is very remarkable in all the species of this order. It consists of a large, pyriform reservoir, sometimes constricted in its middle, and having for the reception of the penis, a canal which opens externally by a special orifice situated below the vulva. In its course this canal sends off a small, flexuous, lateral duct, which passes into the vagina opposite the mouth of the Receptaculum seminis, and thus forms a communication between this last and the copulatory pouch.\(^{23}\)

With the Hymenoptera, the ovaries\(^{20}\) vary very much as to the number of their component tubes, of which there are sometimes four to six, sometimes eight to ten, and with some species they range from twenty to a hundred.\(^{28}\) These tubes are always multilocular, and never very long. The

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\(^{16}\) These tubes are simple with Melophagus, and ramose with Hippobosca.


\(^{21}\) This last-mentioned naturalist has very well figured the female organs of Hippobosca and Melophagus; only he is deceived relative to the glandular appendages of the vagina, in regarding the upper pair as a Receptaculum seminis, but which never contain spermatogenous particles.

\(^{22}\) For the appendages of the female organs of the Lepidoptera, see Siebold, in Müller's Arch. 1837, p. 417.

\(^{23}\) The seminal receptacle has been figured in its various stages of development by Herold (Entwicklungs gesch. d. Schmetterl. Taf. XV. fig. 1, u. y. p. and Taf. XXIV.) as a unicellular secreting organ. See also Suckow, Anat. u. physiol. Untersuch. Taf. VI. g. g.

\(^{24}\) See Herold, loc. cit. Taf. XIII. fig. 1, t. z. and the following plates; also Suckow, loc. cit. Taf. VI. l. l.

\(^{25}\) Melitaca, Argynnis, Zygæna, &c.

\(^{26}\) See Herold, loc. cit. Taf. Xl. fig. 1, x. f. g. and the plates following; also Suckow, loc. cit.

\(^{27}\) § 350, note 23. See also for the internal female genital organs, and especially their development, of the Lepidoptera, Meyer, loc. cit. Siebold Taf. VI. K. (indistinct). Moreover, Malpizhi (De Bombyce, 1663, p. 81, Tab. XII. fig. 1, J. K. 34.) had already perceived, with the silk-worm, all the appendages of the vagina, and specially the copulatory pouch with its canal of lateral communication. With Euproctis Hebe this canal has a pyriform diverticulum.\(^{28}\)

\(^{28}\) For the female genital organs of the Hymenoptera, see L. Dufour, Recherches sur les Orthopt. &c. p. 400.

\(^{29}\) Each ovary is composed of three or four ovigorous tubes with Xyloxyga, Bombyx, Anthophora, Ceratia; of five to six with Nomada, Sapyga, Chalcois, Vespa; of eight to ten with Pimpa, Pan nucus; of ten to twelve with the Tenthredinæ; of twenty to twenty-five with Myrsineæ, Xyphylæa, Banchus; and of more than one hundred with Apis. With Chelonus the ovaries present a remarkable exception; they consist each of two long flexuous tubes, which are very widely dilated at their lower extremity. L. Dufour (loc. cit. p. 541, Pl. X. fig. 120) regards these swellings as a kind of uterus in which are developed the larvæ of these Ichneumonides; but this assertion cannot be admitted without further research.
Receptaculum seminis is nearly always simple, round, or ovoid, and, unless and is continuous into a usually short, seminal duct. A Glandula appendicularis is never absent, and consists, usually, of a bifurcate tube, which opens into the Ductus seminalis, and only rarely into the Capsula seminalis itself.

With the Tenthredinidae this apparatus is, moreover, formed after a different type; the seminal vesicle is a simple diverticulum of the vagina, and more or less distinct from it, beside, it is deficient in the accessory gland. The copulatory pouch is absent with all the Hymenoptera, as are also the Glandulae sebaceae with those females which have a sting and a poison-gland; but these sebaceous glands are highly developed with those species having an ovipositor, into which last they open, and probably serve some purpose connected with the oviposition, partly as sebaceous, and partly as excretory organs. This secretory apparatus consists of a simple or a double ramose gland, whose excretory duct receives the neck of a pyriform receptacle, or, sometimes, is itself dilated into a vesicular reservoir.

With the Orthoptera, the two ovaries are nearly always composed of numerous, multicellular tubes, which usually open in a single row upon the internal or external side of two large and sometimes very long ovaries. The seminal receptacle often consists of a simple longer or shorter pedunculated vesicle, whose closed extremity is dilated into a pyriform vesicle with the Pscociidae, Forficulidae, Locustidae, Phasmidae and Mantidae. A similar Capsula seminis is often found with the Acrididae on one of the sides of the Ductus seminalis and removed from its extremity. Most of the Blat-

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25 For the Receptaculum seminis see Siebold, Observ. quaed. Entom. loc. cit. p. 6, and in German's Zeitsch. IV. p. 362, Tab. II. With those females which, at short intervals, lay very many eggs, the seminal receptacle is very large; see Summerradius, Bib. der Nat. Taf. XIX. fig. 8, loc. cit., where the Receptaculum seminis of a honey-bee is very well represented. 

26 The Glandula appendicularia is simple and inserted on the funiculus with the Pteromalinae and Cyniupidae; it is double, and opens directly into the Capsula seminis, with Psocinae and Tiphinae feminatae. 

The seminal receptacle is double, exceptionally, with Lyda. 

This glandular apparatus is simple and has a sternal pyriform reservoir with various Pselaphidae; see L. Dafour, Recherch. Pl. X. fig. 157-142 (Prophilus et Brachia). This naturalist calls this apparatus Glande sérique, as distinguishing it from the glanule sérique. With Sirex, I have observed the excretory duct of this single and multiramose gland dilated into a large reservoir. With the Tenthredinidae, it is also ramose, but double as well as its vesicular reservoir; see L. Dafour, loc. cit. Pl. X. fig. 155-157 (Penthetra et Umbilicis). 

With the Locustidae, Acrididae, Mantidae and Libellulidae, the ovarian tubes are inserted upon the internal side, and with the Phasmidae and Ephemeridae, on the outer side of the two ovi ducts. Forficula gigantea has, moreover, only five internal multicellular tubes, while with Forfica auricularis, the very long ovaries have on all sides a multitude of unicellular tubes. With Mantis, the ovarian tubes are unilaterial, but united together in several bundles. With Ordipoda ceratocerca and Truxalis nautica, the two long, flexuous, caecal oviducts, have tubes only at their lower extremity. The oviducts of Perla bicandata are still more remarkable; they are very long, flexuous, and have ovarian tubes only on one side of their upper extremity, and anastomose in a loop-like manner. For all these differences, see L. Dafour, Recherch. sur les Orthopt. Sc. Pl. II. V. and Pl. XI. fig. 165, Pl. XII. fig. 296, and in the Ann. d. Sci. Nat. XIII. 1825, Pl. XXI. XXII. (Forficula).

With Forficula, and Acheta, the seminal re ceptacle has a long and flexuous peduncle, which, with the Psocidae, and Locustidae, is shorter. That of Pseuus pulsatilus contains several long- pedunculated, glandular bodies (Nitzsch in German's Magaz. IV. p. 251, Taf. II. fig. 1-5), which I formerly regarded as Capsulidae seminales (Muller's Arch. 1837, p. 410), but which are probably spermaphores. With Perla, the seminal receptacle is a simple cavum, twisted like a ram's horn, and the base of which supports several short glandular follicles (Glandulae appendiculares). For the seminal receptacle of the Orthoptera cited in the text, see especially Körschel, Nachrichten aus dem Sammlung. Tab. IX. fig. 5, k. (Dicticina); L. Dafour, Recherch. sur les Orthopt. Pl. III. fig. 91. Pl. IV. fig. 43 (Acheta and Mantida); and Siebold, Nov. Act. Nat. Cur. XXI. part I. p. 254, Tab. XIV. fig. 7. c. (Locusta).

32 See Hegeschkeiviler, De insect. genitalibus dissert., fig. VII. t. 12; and Siebold, in Muller's Arch. 1837, p. 409, Tab. XX. fig. 3 (Grillys). The Ductus seminalis is usually very long and intertwined, as, for example, with Gryllus, Truxalis, etc.
THE INSECTA.

^ 350.

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tidae^^ and Libellulidae^^ have a short, double, seminal receptacle, which,
however, appears to be wholly wanting with the Ephemeridae.
There is a
round Bursa copulatrix only with the Libellulidae/'*'*'
The glandular
appendages of the vagina are also not found with all the Orthoptera.
They are wanting with the Forficulidae, Phasmidae, Perlidae, Ephemeridae, Libellulidae and Aerididae, but with Decticus and Locusta, there is
a sebaceous organ consisting of a simple, pretty long tube,''"" which, with
the Achetidae, is more or less ramose, and with the Blattidae and Mantidae is
composedof a considerable number of partly simple, partly ramose follicles.'^''
With the Neuroptera, the ovaries consist always of multilocular tubes.
With the Hemerobidae, and Myrmeleonidae, there are ten inserted on the
external side of the two large oviducts, and with the Phryganidae, their
number is quite large, but their insertion on the oviducts is the same.*''"'
The ten with Panorpa, and the much larger number with Sialis, are disposed verticillatc at the extremity of the oviducts.
With Myrmeleon and
Panorpa, the seminal receptacle is a long, pedunculated sac and has, with
Hemerobius, a single, and with Rapkidia, a double Glandula appendicularism With the Phryganidae, this receptacle is still more complicated,
for, beside a long, tortuous accessory gland, which is inserted on the neck,
or at the base of the Capsula seminis, there is, at the lower extremity of
the Ductus seminalis, another and flexuous glandular tube, and a shortpedunculated reservoir which corresponds perhaps to a copulatory pouch.'*'
With Sialis, beside two lateral deverticula serving, probably, as copulatory
pouches, the vagina has numerous vesicular appendages filled with a dark
liquid, but the nature of these is still not understood.'*''
With Myrmeleon,
Hemerobius, and Panorpa, the vagina receives two simple, more or less
flexuous, glandular tubes,'*-* which are probably sebaceous organs, and
with the Phryganidae, consist of six digitiform follicles. ''^'
With the Coleoptera, the ovaries consist of trilocular, rarely multilocular
tubes,'**' which are inserted on thecalyciform upper extremity of the oviducts,
in groups of five to ten or even of fifteen to thirty and forty. '*^'
Beside
;

•53 Rlatta orientalis has two short and fjexuous
seminal receptacles
but Blatta germanica has
two large and two small ones
see Siebold, in
Mulle.r's Arch. 1837, p. 403.
'H The seminal receptacles of Libellula, Aeschna
and Diastatomma consist of two small caeca,
which, with Calopteryx, open into the vagina
through a common duct while, with vigrton, there
is only a single long receptacle ; see Rathki, l)e
Libellular. partibus genital. Tab. I. fig. 11-13, Tab.
II. fig. 12-14, and Tab. III. fig. 9-11, c, and L.
Dufour, loc. cit. PI. XI. fig. 165, d. d. (Libellula,
Aeschna and Agriori). See also my memoir on
the generation of the Libellulidae, iu Germar^s
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35

See Ratkke,

II. fig. 12, 13,

loc.

cit.

and Tab.

36 See Roesel, loc.

Tab.


XIV.

I.

fig.

11-13, Tab.

III. fig. 9-11, b.
Taf. IX. fig. 3,

cit.

loc. cit. p.

i.,

and

255, Tab.

38 For the female organs of the Neuroptera, see
L. Dufour, Becherch. sur les Orthopt. &c. PI.
XII. XIII.
3!) L. Dufour, loc.
cit. PI. XII.
fig. 174, d.
^Panorpa).
*• L. Dufour, Ibid. PI. XIII. fig. 211, 212.
H L. Dufour, Ibid. PI. XII. fig. 188, b. ; and
Suckow, iu Hcusinger's Zeitsch. II. Taf. XVI.
fig.
4.'

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16, d.

L. Dufour, Ibid. PI. XII. fig. 174, 194,
L. Dufour, Ibid. PI. XIII. fig. 211.

37

See C. Dufour, Recherch. &c. PI. HI. fig.
31, d. (Oecantkus), PI. IV. fig. 43 (^Mantis).
It
is not surprising that this wax-apparatus is so
highly developed with the Blattidae and Mantidae,
for, as is known, the females of these insects surruund their eggs with very spacious, multilucular
capsules, which they carry about with them, or
fasten to foreign bodies
see Gaede, Beitr. &c.
Taf. I. fig. 13, 14 (Blatta orientalis), and Roesel,
loc. cit. Th. IV. Taf. XII. (Mantis).
;

By

Carabidae, Hydrocanthari, Cyphonidae, TelephoriT
and Cui'culionidae
in general they are
see Stein,
with the Staphylinidae
Vergl. Anat. &c. p. 2J.
45 The ovaries are multitubular with the Carabidae, Hydrocantliari, ]Iydrophilidae, Elateridae,
Cln-ysomelidae,and Coxinellidae; while with ^;u'o«,
Lixus,a.n<l Hylesinus, there are only two on each
side ; see L. Dufour, Ann. d Sc. Nat. VI. 1825, PI.
XVII.-XX.; Suckow, in Heusinirer's Zeitsch. II.
Taf. XIII., and Stein, loc. cit. Taf. lil.-VIII.
dae,

bilocular

fig. 1, e.

c. c.

of these glands the females of Phry^anea
envelop their eggs with a gelatinous substance
which swells in water and often sticks to stones or
aquatic plants, presenting the appearance of an
aniiular spawn.
44 The ovarian tubes are multilocular with the

means

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these fasciculate, there are also, here and there, botryoidal ovaries, in which there are numerous inbricated tubes inserted on a large calyx of each of the oviducts. When these tubes are few in number, they are but rarely disposed in simple or double regular series. With most species, the Receptaculum seminis is cuneiform and often arcuate; its internal walls are brown, solid and horny, and it communicates with the vagina or copulatory pouch by means of a long, flexuous, spiral Ductus seminalis. With many species, this receptacle is invested with a muscular apparatus, composed of striated fibres, and which undoubtedly is a compressor. Usually, there is, attached to the base of the receptacle, a simple, rarely bifurcate or multiramose, Glandula appendicularis, which is sometimes provided with a long, flexuous excretory duct. Sometimes the entire Receptaculum seminis is composed of only a simple, rarely bifurcate, somewhat long caccum. Most of the Hydrocanthari, and some Carabidae, with which the Ductus seminalis is inserted on the copulatory pouch, have the peculiarity that there arises from the Receptaculum seminis a special Funiculatory canal which opens into the upper portion of the vagina. A Bursa copulatrix exists, generally, in this order. With only a few species, it consists of a simple dilatation of the vagina, but, usually, it is a rather long, muscular caccum, separated from the upper wall of the vagina, and sometimes even flexuous when its length is considerable. Very often, the vagina is quite long, curved S-shaped, and passes with the rectum into a cloaca-like canal. It has a complicated special muscular apparatus. The glandular appendages of the vagina are wanting with the Coleoptera, but, with the Hydrophilidae, there are two multiramose appendages on the oviducts, which are probably sebacous organs. The same function may, perhaps, be attributed to the glandular walls of the upper extremity of the oviducts of the Staphylinidae and Histeridae.
§ 351.

The External Genital Organs of the females are pretty simple with the Aptera, Hemiptera, Lepidoptera, Coleoptera, with many of the Diptera, Orthoptera, and Neuroptera, and with some Hymenoptera. The orifice of the vagina is supported by an upper, and two lateral horny plates, whose size and form vary according to the species. With only some Coleoptera, Diptera, and Hymenoptera, the end of the vagina is protractile, appearing as a more or less articulated *Vagina tubiformis*.\(^1\) These horny plates about the vaginal orifice serve to support the penis during copulation, and to facilitate the escape of the eggs during oviposition.\(^2\) With the Acrididae, these plates are conical, and in two pairs, one upper, and one under, which may be opened and shut in a pincer-like manner. With several genera of the Tipulidae, and Asilidae, the two lateral plates are very long, and form a simple ovipositor (*Vagina bicoudis*).\(^3\) With Boreus, and Acheta, this ovipositor is long, and with *Raphidia*, it is long and acinaceiform. The Lociustidae have also a similar and very prominent ovipositors sabre, but more complicated in that each of its plates is divided into three pieces, which are so disposed that the two internal, soft, are surrounded in a sheath-like manner by the four others, which are horny. With the Tenthredinidae, and with *Aeschna*, *Agrion*, and *Calopteryx*, there is an analogous apparatus situated at the posterior extremity of the abdomen, and covered by two valves, only that its pieces are denticulated in a saw-like manner, and therefore is called saw-ovipositor.\(^4\) With the Siricidae, the ovipositing apparatus is likewise composed of two horny, denticulate plates; but is more auger-like in its form, and, with some species, projects far beyond the short lateral valves.\(^5\)

The Ichnemomidae, Cynipidae, and Cicadidae have a more or less long ovipositor (*Terebra*), composed of two lateral groove-like sheaths, between which plays a kind of sting composed of two intimately-united horny shafts. This sting serves, partly to pierce the substance in which the eggs are to be deposited, and partly to push the eggs along the sheath formed by the groove-like valves.\(^6\) All these different ovipositors have a muscular apparatus at their base, by which their component pieces are moved.

With some Libellulidae, there is a peculiar groove-like appendage on the penultimate abdominal segment. It serves to receive the eggs at the

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1. The ovipositor is unarticulated and protractile with the Cerambycidae, while it is articulated with the Chrysomelidae and many of the Muscidae. In this last case, its pieces are movable, like the tubes of a telescope. They are only the terminal abdominal segments modified; see L. Dafour, *Ann. d. Sc. Nat.* I. 1844, p. 353, Pt. XVI. fig. 16 (*Piphiola*).


3. *Limnobia*, *Ptychoptera*, *Tiphula*, *Ctenophora*, *Asillus*, *Laphria*. Among these Diptera, *Ctenophora ruficornis* is particularly distinguished by the length of the horny plates composing the ovipositor.

4. For the structure of this saw-like ovipositor, see *Lygnet*, *Mem. du Mus.* XIX. p. 57, Pt. VI.-VIII. (14-16) (Marches à soie); and *Hartig*, *Die Adlerflügler Deutschl.* p. 37, Taf. I. u. d. I.; also, *Réaumur*, *Mem. VI.* 11 mem. 4, Pt. XL. fig. 6-9 (*Agrion*). It is well known that these Insects use this ovipositor to pierce the epidermis of plants, and to introduce therein their eggs. The deposition of the eggs with the Tenthredinidae has been described with details by Dohle (Isis, 1837, p. 76) and by Ratzborn (vorsteckten, Th. III. p. 65). I have, also, observed this act with *Agrion forcipula* (Wiegmann's Archiv. 1841, p. 205).

5. Hartig and Ratzborn have given a detailed description of the auger of the Siricidae; it is particularly long with *Nymphidia* and *Sirex*.

moment of their escape from the vagina, and in this way the eggs are collected in masses to be deposited in places fit for their incubation.  

II. Male Genital Organs.

§ 352.

The Testicles, which are double like the ovaries, consist, sometimes of two simple caeca, which are more or less long and torose, and sometimes of many caeca, very variable as to their forms and disposition. Their mode of grouping resembles that of the ovaries; indeed, their whole appearance and contour, and the number and composition of their various parts resemble remarkably those of the female organs. With many species, these organs are covered by a lively-colored pigment layer, or enveloped by a special membrane (Tunica vaginalis).

The two Vasa deferentia are of variable length, often exceeding that of the body, and therefore making several convolutions in the abdominal cavity. When the testicles are composed of many caeca, there are often the same number of these canals; but they often unite, on each side, into a common duct. Sometimes they have, each, at their lower extremity, a vesiculæ dilatation which may be regarded as a Vesicula seminalis. At their point of junction on the Ductus ejaculatorius, there are usually situated two, longer or shorter, simple Glandulae mucosae, which secrete a quickly coagulating, granular mucus, which serves, during the copulatory act, partly to fill and distend the Bursa copulatrix together with the penis, and partly to surround portions of the sperm, and thereby form spermatotheces.

§ 353.

The principal modifications observed with the internal male organs of the Insecta, are the following.

Among the Aptera, Lepisma is distinguished in having numerous oval, testicular follicles, whose Vasa deferentia, after forming irregular ramifications, unite in two common excretory ducts, which, gradually enlarging, terminate in a Ductus ejaculatorius at the point of insertion of two arcuate accessory glands.  

With the Hemiptera, the internal genital organs are of very variable form. The Pentatomidae have only two simple, pyriform testicles, often of a beautiful red color; at their free extremity they sometimes have several constrictions, and thus form the passage to the form proper to many Geocorisæ, which have seven long testicular tubes united in a fan-like

7 The ovigerous groove is short and triangular with Lebieda vulgaris and coccinellata; long, acuminate, and perpendicular with Cordulia metallicæ; long and cordately emarginate and closely applied against the abdomen with Ephippus bimaculatus. A remarkable appendage, deeply excavated, situated to the exterior of the female genital organs of Doritis Apollo and maculonoe, and upon which, as yet, no lepidopterist has given any details, is probably an ovigerous sac.

1 For the various forms of the simple and compound testicles, as well as for the male organs of the Insecta in general, see Burmeister, Handb. &c. I. p. 247, and Lecardier, Introd. &c. II. p. 505.

2 See Treviranus, Verm. Schrift. II. p. 15, Tab. IV. fig. 2. The Policieidae have only two pairs of testicles.
§ 353. THE INSECTA. 459

manner. They sometimes these seven tubes are grouped into a bundle at the upper extremity of each of the two deferent canals. With the Cicadidae, the testicular tubes are extremely numerous and fasciculate in the same manner; while with Psylla, there are only four, and with Aphis, only three on each side. The Hydrometridae have only two or four long testicular follicles, on the sides of which arise the deferent canals. With Pelogonus, and Notonecta, there are two pairs of long, spiral tubes, while with Nepa, and Ranatra, there are five on each side, long and flexuous. The Vas deferentia are short with most of the Geocoridae, the Pyorrhinae and the Aphididae; but with the Hydrocorisae, and the Cicadidae, they are long and intertwined. The glandular appendages are highly developed with most Hemiptera and often open into the two deferent canals above the Ductus ejaculatorius. But when these glands appear to be wanting, the deferent canals have upon their course, or at their extremity, vesicular dilata-
tions which, perhaps, take their place. With the Pentatomidae, the glandular appendages consist of two to four multitramose fasciculate tubes. The Ductus ejaculatorius is then dilated at its base into a kind of vesicle divided into two or three lobes, which serve probably as mucous reservoirs.

With the Diptera, the male organs are much more simple, there never being but two simple testicles, whose external envelope is often brown or yellow. These organs are usually pyriform or oval, but sometimes long or hooked or twisted in various ways. The Vas deferentia are usually of considerable length, and open in the upper end of the Ductus ejaculatorius, always in common with two simple and pretty long accessory glands.

With the Lepidoptera, the testicles are always composed of two round or oval follicles, often surrounded by a beautifully colored pigment. Very often, also, they are so approximated on the median line of the abdomen, as to appear fused into a single round body. The two deferent canals, after a short course, unite with two simple, long and very flexuous accessory glands, and then form a very long and torose Ductus ejaculatorius. 3

3 Coreus, Myopus, Pyrrhocoris, Acantlia.
4 Capsus, Miris, Aradus.
6 With Aphis lioncerae, the six testicular tubes are concomitant on the median line of the abdominal cavity, so that they might easily be taken for a single body; see my observations in Frcrpei's neue Notiz. XII. p. 307. According to Morren's description (Ann. d. Sc. Nat. 1839, p. 87, Pl. VI.), there would appear to be a real fusion of the testicular tubes with Aphis pseuderac.

7 With Aradus, Nepa, Ciecura, Aphrophora, the two simple glandular appendages, which are extraordinarily long and flexuous with the Claudiidae, are inserted on the sides of the deferent canals; while with Aphis, which has two, and with Notonecta, Miris and Capsus, which have four, the glandular tubes open into the Ductus ejaculatorius, conjointly with the deferent canals.

8 Psylla, Pyrrhocoris, Veilia and Gerris. L. Dufour (Recherches, &c.) unhappily calls these dilations of the deferent canals Vesicula seminalis.
9 L. Dufour (Recherches, &c. Pt. X.) also regards this reservoir as a Vesicula seminalis.

10 The male organs of the Diptera have been described by L. Dufour (Ann. d. Sc. Nat. I. 1844, p. 250), and by LeCoe (Horse Antl. p. 9, Tab. 1-III.), whose account is very detailed and exact.
11 The testicles are long and regularly flexuous with Myopa, spiral-form with Astius and Basysphora, while those of the Hippoboscidae are extremely long and very torose; see L. Dufour, Ann. d. Sc. Nat. loc. cit.
12 Stratocomeus, alone, has very long and torose deferent canals.
13 These two glands are very long with Hippobosca, Doliachopus, Astius, and Stratocomeus; flexuous with Trygeta and Petia; with Leptis, they are wanting, being replaced, probably, by two swellings situated at the lower extremity of the two deferent canals. Empis and Scatophus have two pairs of glands, one above, the other below.
14 The testicles are carmine-red with Argyromus, Hypercorba, Pontia and Liparis; green with Hesperis.
15 Suckow (Heurigier's Zeitsch. II. Taf. X. fig. 10) has found two separated testicles with Eumon-
centa. The fusion of these organs is complete with the Papilionidae, Sphingidae, Bombyx, &c.
16 See Herold, Entwicklungsgesch. d. Schmet-
tterl. Taf. IV. XXXII. (Pontia brassicic)
With the Hymenoptera, the testicles present many different forms. Beside two simple ovoid testicular follicles there are, not unfrequently, also two testicles composed of several long follicles, fasciculate, and surrounded, together with a portion of the torose deferent canal, by a common envelope; but, more commonly, these two testicles are contained in a capsule situated on the median line of the body.

With the Teuthredinidae and the Siricidae, the testicles are separate and distinct, without capsules, and composed of round follicles disposed botryoidally. The two deferent canals are usually pretty long, and have, sometimes, at their lower extremity, two vesicular dilatations which, containing sperm, may be regarded as seminal vesicles. The deferent canals with the Hymenoptera have, usually, two pyriform accessory glands, whose excretory ducts unite into a short Ductus ejaculatorius.

With the winged Strepsiptera, there are two pyriform testicles provided with very short deferent canals, which dilate above the Ductus ejaculatorius into two seminal vesicles; but nowhere has an accessory gland been observed.

With the Orthoptera, the two testicles are nearly always composed of a greater or less number of follicles. With the Acrididae, Locustidae, Achetidae, Blattidae and Mantidae, they are composed of long fasciculated or imbricated cannae, which, as with the Hymenoptera, are very often surrounded by a common envelope. In some species the two groups of testicular follicles are united into a common mass on the median line of the abdomen, by this Twica vaginalis. On the other hand, the Phasmatidae, Libellulidae, Periidae and Ephemeridae, have a multitude of round follicles, disposed botryoidally around a long dilated portion of each of the deferent canals. These last are usually very short, and with the Achetidae and Locustidae, only, they are quite long, and spiral from beginning to end. Many Orthoptera have highly-developed accessory glands surrounding a short Ductus ejaculatorius, on which they are sometimes disposed in successive groups. A part of this apparatus, in which are

Nucke, Ausl. u. physiol. Untersuch. Taf. IV. (Gastrupneca pinii).

L. Dufour (Recherch. sur les Orthopt. p. 559, Pl. V–X.) has furnished observations accompanied with very many figures on the male organs of the Hymenoptera.

The testicles are simple with_Parnopes, Cyriis, Diplotepis and Chelonus.

There are two unicapsular testicular bundles with_Apis, Xylocopa and Bombus; see L. Dufour, loc. cit. fig. 55-62. The two testicular fasciculi are enclosed in a common capsule with_Antithora, Anthidium, Odynerus, Tiphia, Scelis, Pompilus and Crabro; see L. Dufour, loc. cit. Pl. VI–IX.

L. Dufour, loc. cit. fig. 150-154 (Teuthredo, Hyaloptera and Cephus).

The deferent canals terminate each with a seminal vesicle with_Cyriis, Chelonus, Apis and Xylocopa.

See Brandt and Rotzberg, Mediz. Zool. Taf. XXV. fig. 35 (Apis), and L. Dufour, loc. cit.

See L. Dufour, Recherch. sur les Orthopt. Pl. I–V. There are two distinct fasciculated testicles with_Grytolalpa, Oecanthus, Ephyippiger, and two groups of long, fasciculated follicles with_Tetrix, Locusta and Decticus. The testicles are fused into one body with_Oedipoda and Blatta.

See Nucke, in Hensinger's Zeitsch. H. Taf. XII. fig. 25, Taf. X. fig. 8; Rothke, in Libellul. partibus genital. Tab. l. fig. 3, and L. Dufour, loc. cit. Pl. II. fig. 164, and Pl. XII. fig. 204 (Perla and Libidulata).

See L. Dufour, loc. cit. fig. 25, 36 (Grytolalpa and Ephyippiger).

The Perdidae have only two testicular follicles inserted on the deferent canals. Tetrix, the Acrididae, Achetidae and Blattidae, have two long and large fasciculi; finally, with the Mantidae and Locustidae, there are, besides these fasciculi, one or two pairs of shorter bundles; see L. Dufour, loc. cit. Pl. III–V.

* See also, for histological details on the internal male organs and their development, of the Lepidoptera, Meyer, loc. cit. Sibbold and Kolliker's Zeitsch. 1. 1849, p. 182. The formula of the development of the testicles is, of course, the same as that of the development of the ovaries; but this observer shows that the spermatogenic particles are formed, like the ova, while the insect is in the pupa-state. — Ro.

† See also, Leidy, Proceed. Acad. Sc. Philad. 1846, 111. p. 80 (Spectrum femoratum). — Ro.
situated here and there vesicular reservoirs, secretes, undoubtedly, with the Locustidae, a substance used in the formation of the spermatophores. But with the Phasmiidae, Libellulidae and Ephemeridae, the Ductus ejaculatori-rius is wholly deficient in all kinds of glandular appendages.

With the Neuroptera, the various genera present only few modifications in their male genital organs. With Panorpa, the two testicles are very simple and ovoid;[25] but with the other species they consist of two tufts of long or round follicles.[26] With Myrmelton, and Hemerobius, they are oval and surrounded by a distinct envelope. The two deferent canals are short, and always have on their lower extremity two long or ovoid accessory follicles.[26]

With the Coleoptera, the male organs vary very much.[26] With the Carabidae, Hydrocanthari, and Lucanidae, the testicles consist of two extremely long, torose caeca,[26] of which each is sometimes enclosed in two special envelopes.[26] The Elateridae, Tillidae, Cantharidae, very many Heteromera and Coccinellidae, have, on the other hand, a multitude of round or oblong, short follicles, fasciculate, composing the two testicles, which,[26] in some genera, are here also invested by a capsule.[27] With the Hydrophilidae, and Pyrochroïdeæ, these organs are composed of numerous short, aggregated follicles, situated laterally over a wide extent of the posterior extremity of the deferent canals.[26] With the Staphylinideæ, and Silphideæ, the testicular follicles are pyriform and inserted botryoidally on the posterior extremity of the simple or multiramose Vasa deferentia.[26] With the Lamellicornæ, Cerambycidae, Curculionidae, and Criocerideæ, these organs are formed after a wholly different type, their number being two, six, or even twelve on each side. They are usually round follicles, flattened disc-like, and from which pass off pretty short excretory ducts to the extremity of the two common deferent canals.[26]

The Vasa deferentia, with the Coleoptera, are usually pretty long; but with the Carabidae, Hydrocanthari and Cerambycidæ they are very long, spiral or torose.[26] With a few species, only, is each of them dilated in its course into a Vesícula seminalis.[26] The accessory glands are never wanting in this order, and they either open, together with the deferent canals, into the upper extremity of the Ductus ejaculatorius, or they pass into these canals before they reach this duct. In very many species this gland-

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25 L. Dufour, loc. cit. fig. 172.
26 See Sistis and Phryganæa.
27 See L. Dufour, loc. cit. Pl. XII. fig. 172-210 (Panorpa, Myrmelton, Sistis, Phryganæa), and Suckow, in Heusinger's Zeitsch. II. Taf. XVI. fig. 15 (Sistis).
28 For the male organs of the Coleoptera in general, see especially L. Dufour, Ann. d. Sc. Nat. VI. 1825, p. 192, PI. IV.-IX. and 1834, p. 76, PI. III. IV.
29 With Harpalus, the two caeca are united into a single claw.
30 Clysster, Scardina, and Cletina, have two testicles invested by a capsule.
31 Each testicular fasciculus is composed of from three to seven follicles with Dermestes, Heteroceros, Anthrocerus, Odacerna, Helops, Dicerca, Penebroi; while with Hips, Pimpelia, Mylabris, Telephorus, Borschius, the Elateridae and Coccinellidae, their number is much larger.
32 There is a Tunica tunicis with Cletus, Tria-chois, Mylabris, and which, with Galerucæ, is even common to both testicles.
33 See Swammerdamm, Bib. der Nat. Taf. XXII. fig. 5; Suckow, in Heusinger's Zeitsch. II. Taf. X. fig. 3; 2 (Hydrophiles); L. Dufour, Ann. d. Sc. Nat. XIII. 1840, Pl. VI. A. fig. 18 (Pyrockrae).
34 The two testicles are multoramose with Silphy; see L. Dufour, Ann. d. Sc. Nat. VI. 1825, Pl. VI. fig. 6.
35 Hemomachères, Anthribus, Lixus and Do- necia have two pairs of testicles; Melotonida and Priouës six, Prélùtris nine, and Cetonia twelve. Beside L. Dufour (loc. cit.), see Suckow, in Heus- inger's Zeitsch. II. Taf. XI. and Straus, Consid- erat., &c. Pl. VI.
36 These torosities are even surrounded with a capsule with Clysster; see L. Dufour, Ann. d. Sc. Nat. VI. 1825, Pl. V. fig. 1.
37 With the Hydropholidæ, there is a vesicular dilatation at the lower extremity of the deferent canals; but with Anthribus, and Lixus, it is situated at the opposite extremity.
ular apparatus consists of only two simple, longer or shorter caeca,\(^6\) which are sometimes quite long and torose.\(^11\) Another series of Coleoptera have four to eight caecal appendages, disposed in pairs, and variable as to length and volume. One of these pairs is probably only a reservoir for the secreted product of the others.\(^42\) The *Ductus ejaculatoius* is always very muscular, and with very many species, quite long and flexuous, and the penis therefore can be widely protruded during copulation.

§ 354.

The Copulatory organs of the male Insecta are valve-like or forniculate, horny appendages,\(^3\) which are so variable in their form that the most allied species differ, in this respect, widely and constantly.\(^2\)

Beside these proper copulatory organs, situated at the posterior extremity of the abdomen, there are often on the antennae, the parts of the mouth, the legs and other regions of the body, auxiliary organs used for seizing and retaining the female, and which have long been objects of careful description in zoology.

With most Hemiptera, the posterior extremity of the abdomen conceals a horny capsule which contains a protractile, tubular penis. With very many Diptera, the copulatory organs project prominently in the same region of the body, and consist often of two horny valves of different forms which envelop a rather long penis.\(^3\) The Lepidoptera, Hymenoptera, Orthoptera, and Neuroptera, have two pairs of valves, one internal, the other external, which enclose a tubular or groove-like penis.\(^6\)

The Ephemeridae and the Strepsiptera, only, are distinguished by their very simple copulatory organs; for with the first there is only a simple penis without a valvular apparatus. This last is replaced by two long, small, triarticulated styles, situated on the penultimate abdominal segment and curved inwardly; while with the Strepsiptera, the penis, also naked and horny, is so articulated that it can be applied laterally against the abdomen, like the blade of a knife in its handle.

With the Libellulidae, however, the orifice of the *Ductus ejaculatoius* is most simple, being covered only by two very small oval valves. But the penis is not wanting with these Insecta; it is singularly concealed, together with a horny-walled seminal vesicle, in a fossa situated at the base of the

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\(^6\) With the Carabidæ, Hydrocarabini, and with *Mordella, Anthisus, Gasteruca* and *Coccusella*.

\(^3\) *Melolontha, Cetonia* and *Lacanus*; see L. Dufour, Stemm, and Suckow, loc. cit.

\(^4\) With the Staphylinidæ, Cantharidæ, Byrrhidæ, Heterobinæ, Tachinidæ, *Mecodæ*, Tenebrionidæ, *Pyrochridæ*, *Dermestidæ*, *Cerambycidæ*, with *Dananjoll*, *Heterocerus*, &c.; see L. Dufour, Suckow, loc. cit. and Brandt, Molis, Zool. Taf. XVII. XIX. This glandular apparatus is specially developed with *Hydrophilus pinguis*, where, of the four pairs, one is distinguished for its length and thickness, and is composed at its extremity of numerous small follicles; see *Sauemmerdorum*, Lib. der Nat. Taf. XXII. fig. 4; L. Dufour, loc. cit. VI. Pl. VI. fig. 7, and Suckow, loc. cit. Taf. X. fig. 3, 5.

\(^5\) See Burmeister, Handb. &c. I. p. 227, Taf. XIII.

\(^6\) As yet, these differences in form of the external male organs have been of but little service to entomologists in the distinction of species, although, had they been well understood, the formation of many bad species might have been prevented. They prevent allied species from producing bastardy by adulterous connections, for the hard parts of the male correspond as exactly with those of the female, that the organs of one species cannot fit those of another. L. Dufour has, therefore, properly termed these copulatory organs as "la garantie de la conservation des types, et la sauvegarde de la légitimité de l'espèce."

\(^7\) This horny apparatus, from its large and often tufted lateral valves is quite prominent when the Dolichopodæ, Embicine, with *Asilus*, *Laphroa*, *Ctenophora*, *Nematoxena*, and other Tipulidæ, Sec. *Schummmel*, Beitr. zur Entomol. Taf. I. 111. (Tipizes)."
§ 855. THE INSECTA.

abdomen. This penis is composed of three articles with Aeschna, Libellula, and Gomphus; but of one only with Calopteryx, and Agrion, with which it is not directly adherent to the seminal vesicle. The male Libellulidae are obliged, before copulation, to fill their vesicula seminalis, which is situated at the base of the abdomen. This they accomplish by bending the posterior extremity of the abdomen, so as to meet and empty the semen into this vesicle. They then seize the female by the neck, by means of their anal pincers, and she places her genital orifice in contact with the copulatory apparatus of the male. These anal pincers of the males have very distinct specific characteristics, while the females, on their part, have, in the separate species, equally specific sculptured markings on the prothorax.

With the Coleoptera, the copulatory organs consist of a more or less horny sheath enveloped by a membranous prepuce, and containing a broadly-flattened penis which consists of a canal supported by two lateral horny ridges. At rest, these organs are entirely withdrawn into the abdominal cavity, but can be widely protruded out of it by means of a very remarkable muscular apparatus. With the male individuals of Dermecestes, there is a median orifice on the third and fourth abdominal segments, from which projects a brush of stiff bristles connected with a round muscular body situated on the internal surface of each of these segments. This brush is undoubtedly some way connected with the act of copulation.

§ 855.

The development of the larvae of Insecta in the egg, occurs in the same manner as with most of the other Arthropoda. After the unusually early disappearance of the germinative vesicle, there is formed, from a superficial and partial segmentation, a round or oblong-oval blastoderm, whose hyaline aspect contrasts with that of the rest of the vitellus. This blasto-
toderma, which corresponds to the ventral side of the future embryo, extends gradually in all directions and at last encompasses the whole vitellus,—its borders meeting on the dorsal surface. It may be divided into an external or serous, and an internal or mucous layer. In the first of these is developed, on the median abdominal line, the ventral canal; while the second forms a semi-canal which gradually surrounds the vitellus and at last completely enveloping it, is changed into the digestive canal. The various appendages of this canal are subsequently formed by simple constrictions or deverticula from its cavity; while the other abdominal viscera are directly developed from a special blastoderm.

Upon the external surface of the serous layer are formed the parts of the mouth, the tactile organs, the legs, and the other appendages of the body, whose articulations, like those of the body itself, are produced by constrictions.

The dorsal vessel is formed between the two blastodermic layers on the side opposite that of the ventral canal. This development of the embryo takes place at the expense of the vitellus, which, enclosed in the digestive canal, is gradually consumed.*

* [End of § 355.] The subject, which has been frequently alluded to in this book,—the singular mode of reproduction of the viviparous Aphididae, is one of so much interest and importance in physiology, that I propose to give it something more than a brief mention. Moreover, I have enjoyed excellent opportunities for the study of these phenomena in question, and have advanced an interpretation of them, and their like elsewhere, quite different from that usually received.

My observations were made upon Aphis carpoae (probably Lachnus of Illiger, or Cinara of Curtis), one of the largest and most favorable species for these investigations. This was in the spring of 1853. The first colony, on their appearance from their winter quarters were of mature size, and contained, in their interior, the developing forms of the second colony quite far advanced in formation. On this account it was the embryology of the third series or colony, that I was able to first trace. A few days after the appearance of the first colony (A), the second colony (B), still within the former, had reached two-thirds of their full embryonic size; the arches of the segments had begun to close on the dorsal surface, and the various appendages of the embryo were becoming prominent; the alimentary canal was more or less completely formed, although distinct abdominal organs of any kind belonging to the digestive system were not apparent.

At this time, and while the individuals B. were not only in the abdomen of their parents A., but were also enclosed each in its primitive egg-like capsule; at this time, I repeated the first traces of the germ of the third colony, C. Their first traces consisted of small egg-like bodies, arranged two, three, or four in a row, and attached at the locality where are situated the ovaries in the oviparous forms of the Aphididae. These egg-like bodies were either single nucleated cells of one three-hundredth of an inch in diameter, or a small number of such cells enclosed in a simple sac. These are the germs of the third generation or colony, and they increase pari passu with the development of the embryo in which they are formed, and this increase of size takes place not by the segmentation of the primitive cells, but by the endogenous formation of new cells within the sac. After this increase has continued for a certain time, these bodies appear like little oval bags of cells,—all the component cells being of the same size and shape,—there being no one particular cell which is larger and more prominent than the others, and which could be comparable to a germinatine vesicle. While these germs are thus constituted the formation of new ones is continually taking place. This occurs by a kind of constriction-process of the first germ; one of the ends of these last being pinched off, as it were, and so, what was before a single body or sac, becomes two which are attached in a moniliform manner. The new germs thus formed may consist each of a single cell only, as I have often seen; but they soon attain a more uniform size by the endogenous formation of new cells within the sac in which it is enclosed. In this way the germs are multiplied to a considerable number, the nutritive material for their growth being, apparently, a fatty liquid in which they are bathed, contained in the abdomen, and which is thence derived from the abdomen of the first parent. When these germs have reached the size of about one three-hundredth of an inch in diameter, there appears on each, near the inner pole, a yellowish, vitellus-looking mass or spot, composed of yellowish cells, which, in size and general aspect, are different from those constituting the germ proper. This yellow mass increases after this period, pari passu with the germ, and at last lies like a cloud over and partially concealing one of its poles. I would, moreover, insist upon the point that it does not gradually extend itself over the whole germ-
mass, and is, therefore, quite unlike a proligorous disc.

When these egg-like germs have attained the size of one one-hundred-and-fiftith of an inch in diameter, there begins to appear distinctly the sketching, or marking out of the future embryo. This sketching consists at first of delicately-marked retractions of the cells here and there; but these last soon become more prominent from subulations, and, at last, the form of an articulated embryo is quite prominent.

During this time, the yellowish, vitellus-looking mass has not changed its place, and although it is somewhat increased in size, yet it appears otherwise the same. When the development has proceeded a little further, and the embryo has assumed a pretty definite form, the arches of the segments, which have hitherto remained gapingly open, appear to close together on the dorsal surface, thereby enclosing the vitellus-looking mass within the abdominal cavity. It is this same vitellus mass thus enclosed, which furnishes the development of the new germ (which in this case would be those of the fourth colony, or D), and this germ development here commences with the closing up of the abdominal cavity, and then the same processes we have just described are repeated.

The details of the development subsequent to this time,—the formation of the different systems of organs, &c., are precisely like those of the development of true oviparous Arthropods in general; and although the ovum germ has, at no time, the structural peculiarities of a true ovum,—such as a real vitellus, germinal vesicle and dot, yet if we allow a little latitude in our comparison and regard the vitellus-looking mass as the mucous, and the germ-mass proper as the serous fold of the germating tissue, as true ovum; if this comparison of parts can be admitted, then the analogy of the secondary phases of development between these forms, and true ova of the Arthropods, can be traced to a considerable extent.

These secondary phases of development need not here be detailed, for they correspond to those described by Herold, Klücker, of the true ovum in other Insecta, and which, too, I have often traced in various species of the Arthropods in general.

When the embryo is fully formed and ready to burst from its capsule in which it has been developed, it is about one-sixteenth of an inch in length, or more than eight times the size of the germ, when the first traces of development in it were seen. From this last-mentioned fact, it is evident that, even admitting that these germ-masses are true eggs, the conditions of development are quite different from those of the eggs of the truly viviparous animals, for, in these last, the egg is merely hatched in the body instead of out of it, and, moreover, it is formed exactly as though it was to be deposited, and its vitellus contains all the nutritive material required for the development of the embryo until hatched. With the Aphidline, on the other hand, the developing germ derives its nutritive material from the fatty liquid in which it is bathed, and which fills the abdomen of the parent.

The conditions of development in this respect, are here, therefore, more like those of the Mammalia and the whole parent animal may be regarded in one sense as an individualized uterus filled with germs,—for the digestive canal with its appendages seems to serve only as a kind of laboratory for the conversion of the succulent liquids this animal extracts from the tree on which it lives, into this fatty liquid which is the nutritive material of the germ.

Omitting the curious and interesting details of the further history of the economy of these Insecta, as irrelevant to the point in discussion, we will now turn to see what view we should take of these processes, and what is their physiological interpretation. In the first place it is evident that the germs which develop these viviparous Aphididae are not true eggs; they have none of the structural characteristics of these last,—such as a vitellus, a germinal vesicle and dot; on the other hand they are at first simple collections, in oval masses, of nucleated cells. Then again, they receive no special fecundating power from the male, which is the necessary preliminary condition of all true eggs; and furthermore the appearance of the new individual is not preceded by the phenomena of segmentation, as is also the case with all true eggs. Therefore, their primitive formation, their development and the preparatory changes they undergo for the evolution of the new individual, are all different from those of real ova.

Another point of equal importance is these viviparous individuals of the Aphididae have no proper ovaries and oviducts. Distinct organs of this kind I have never been able to make out. The germs, as we have before seen, are situated in moniliform rows, like the successive joints of coniferous plants, and are not enclosed in a spiril tube. These rows of germs commence, each, from a single germ-mass which sprouts from the inner surface of the animal, and increases in length and, the number of its component parts by the successive formation of new germs by the constriction process as already described. Moreover, these rows of germs which, at one period, closely resemble in general form, the ovaries of some true Insecta, are not continuous with any uterine or other female organ, and therefore do not at all communicate with the external world, on the other hand, they are simply attached to the inner surface of the animal, and their component germs are detached into the abdominal cavity as fast as they are developed, and thence escape outwards through a Porus scutellus.

With these data, the question arises, what is the proper interpretation to be put upon these reproductive phenomena we have just described? My answer would be that the whole constitutes only a rather anomalous form of gemmiparity; as already shown, the viviparous Aphididae are sexless; they are not females, for they have no female organs, they are simply gemmiparous, and the budding is internal, instead of external as with the Polypyl and Acalepha; moreover this budding takes on some of the morphological peculiarities of oviparity but there
peculiarities are economical and extrinsic, and do not touch the intrinsic nature of the processes therein concerned. Viewed in this way, the different broods or colonies of Aphididae cannot be said to constitute as many true generations, any more than the different branches of a tree can be said to constitute as many trees; on the other hand the whole suite, from the first to the last, constitute but a single true generation. I would insist upon this point as illustrative of the distinction to be drawn between sexual and gemmiparous reproduction. Morphologically, these two forms of reproduction, have, it is true, many points of close resemblance, but there is a grand physiological difference, the perception of which is deeply connected with our highest appreciation of individual animal life.

A true generation must be regarded as resulting only from the conjugation of two opposite sexes, — from a sexual process in which the potential representatives (spermatic particle and ovum) of two opposite sexes are united for the elimination of one germ. The germ power thus formed may be extended by gemmation or fission, but it can be formed only by the act of generation, and its play of extension by budding or by division must always be within a certain cycle, which cycle is recommended by the new act of the conjugation again of the two sexes. In this way the dignity of the ovum as the primordium of all true individuality, is maintained.

I have thus treated this subject in some detail, not only from its wide bearing in the physiology of reproduction, but also from its direct relation to many phenomena alluded to in the preceding pages. In the memoir from which I have made this extract (read before the Amer. Acad. Arts and Sc., Oct. 11, 1850) I have entered into a full discussion of those many points suggested by these studies. One of these, is, the relation of this subject to some of the various doctrines of development, which have been advanced in late years, such as that of Alternation of Generation, by Stein-strup, and that of Parthenogenesis by Owen. I have there attempted to show that the phenomena of these doctrines, as advanced by their respective advocates, all belong to those of gemmiparity, and that therefore Alternation of Generation and Parthenogenesis in their implied sense, are misnomers in physiology. Another point there treated in extenso, is the identity of this mode of reproduction we have just described in the Aphididae, with that observed in the so-called hibernating eggs of the Entomostraca (see above, § 290) and the like phenomena observed in nearly every class of the Invertebrata. They are all referable, in my opinion, to the conditions of gemmation, modified in each particular case, perhaps, by the economical relations of the animal.

See for some recent writings on this peculiar form of reproduction with the Insecta, and which contain many interesting physiological remarks, Lepidig, Die Dotterfurchung nach ihrem Vorkommen in der Thierwelt und nach ihrer Bedeutung, in der Isie, 1848, Hft. 3; also, Einige Bemerkungen über die Entwicklung der Blattläuse, in Siebold and Kuhl's Zeitsch. II. 1850, p. 62; also Zur Anatomie von Coccus hesperidum, in Ib. 1853, V. p. 1; Victor Carus, Zur näheren Kenntniss des Generationswechsels, Leipzig, 1849; and Siebold, as referred to in my note under § 543 note 4. I cannot here discuss the often similar and dissimilar views to these of my own above detailed, expressed by these different investigators. — En.
INDEX.

ABBREVIATIONS.

Acal., Acalypheae.
Aceph., Acephala.
Ann., Annulides.
Arach., Arachnoidea.


Rhiz., Rhizopoda.
Hel., Helmintes.
Inf., Infusoria.
Ins., Insecta.
Pot., Polypl.

N. B. The Numbers refer to the Paragraphs.

A.

Acalephae, 55.
Acephala, 170.
Acalyphi, Ann. 145.
Air cavity or reservoir, Acal. 65.
Ambulasera, Ech. 77, 91.
Ampulla, of Poli, Ech. 92.
Annulides, 142.
Ampulla, Inf. 15. Ech. 82. Hel. 107. Rot. 156.
Aceph. 189, 189. Cep'h'l. 214. Cep'h'd. 249.

Apparatus, ceraceous, Ins. 347.

— digestive. Inf. and Rhiz. 11. Pol. 35.

Acal. 61, Ech. 82. Hel. 106. Turb. 125.
Rot. 156. Ann. 152. Aceph. 188. Cep'h'r.

— ejaculatory, of sperm. Cep'h'd. 259.

— mastacambly. Ech. 84. Hel. 108. Rot.
Crus. 279. Arach. 306. Ins. 337.

— mucus. Ins. 349.

Acal. 63. Ech. 89. Hel. 112. Turb. 126.
Ins. 341.

— rotator. Rot. 333.

— sebaceous. Ins. 349.


327, 338.

— trunciacular. Ech. 83.


Appendicles, caecal. See Caecum.

Arachnoidea, 295.
Arms. Aceph. 185. Cep'h'd. 237.
Arteries. See Circulatory System.
Audition. See Auditive Organs.

B.

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193. Cep'h'r. 220. Cep'h'd. 255. Crus. 255.
Arach. 312. Ins. 342.
Bursa Needhami. Cep'h'd. 259.
Byssus. Aceph. 179.

C.

Ins. 358.
Caca, hepatic. See Liver.
Calanistrum. Arach. 315.
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— stony. Ech. 75.
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