A home made beautiful by the plants which surround it.
PLANT LIFE AND PLANT USES

AN ELEMENTARY TEXTBOOK
A FOUNDATION FOR THE STUDY OF
AGRICULTURE, DOMESTIC SCIENCE
OR COLLEGE BOTANY

BY

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Coulter, Plant Life.
E-P 4
PREFACE

This book is for boys and girls who study about plants. It is a book about the fundamentals of plant life, and about the relations between plants and man more than it is a "textbook of botany." Yet it presents, as fully as the author believes to be desirable in required courses, those large facts about plants which form the present basis of the science of botany. These facts also form, it is believed, a minimum of knowledge about plants to which every high school student is entitled. To present this minimum adequately, rather than lengthily to cover a maximum, has been the aim.

Appreciation. — The book seeks to give its reader a certain appreciation of plants and of the relationship of plant life to his own life. The study of "botany" may or may not yield such appreciation. Boys and girls by mere accumulation of "organized knowledge about plants" may never come to that appreciation of plants as a part of life which is believed to be very desirable, and one of the proper ends of the study of plants in high schools.

Delimitations. — The book presents the large essentials of plant life. It emphasizes their significance to man. But it does not pile up specific illustrations and applications which may not illustrate or apply in what is common to the lives of high school students in general. The effort is to include what has proper place in the education of all young people, and to exclude special information which properly has required place only in the education of some young people. Thus, as to agriculture, it is believed that such general study of plants as is presented herewith should precede the special study of that subject, but it is doubted
whether such study of plants as is required of all students should be a study primarily of agriculture. In so far as is possible, plant life is presented in this book in terms of its largest relations to human life, but the treatment has in view preparation for life in general, and not preparation for any particular kind of calling.

Forestry, Plant Breeding, Weeds, Plant Enemies and Diseases, Plant Culture, Decorative Plants, and Economic Bacteria are topics which are discussed where such discussion seems pertinent to the general theme, but special chapters are not devoted to these topics. Certainly such topics should form a part of the course, especially if it is a year course, but it is questionable whether special chapters on such topics should form a part of the basic text. Such topics, treated in separate chapters, seriously impair that unity of organization which should characterize a foundational text. Also they form that part of the course which the teacher needs to organize largely in terms of the locality. A treatment of the fundamentals of plant life may fit all cases, but any treatment of the topics given above will not fit all cases, and the misfits may do the cause of practical plant study more harm than good. Thus town children and parents have rebelled against plant studies which are purely agricultural. Finally, government and state bulletins of local application and works of reference have been found to be of much better service in the study of such topics than any brief miscellany of facts put together in "special chapters."

Coherence. — The pupil's facts should hang together for him. In this sort of course he needs to see relationships. This outcome may hardly be expected when there is an overload of facts included for their own sake and at the expense of the course as a whole. Like plants themselves,
courses dealing with plants are often in need of pruning in the interest of the fruit desired.

It is a pruned-back course which is presented herewith, even though the informal style of presentation may lead the reader sometimes to think it otherwise. Omissions have been weighed equally with inclusions. In the interest of a certain end in view, whatever seemed dispensable has been dispensed with. That certain end in view is a broad and a true conception of plants and of their principal relations to mankind. If our subject is to be a science, and not a mere mass of information, then such a conception is the first claim upon plant knowledge which we are called upon to satisfy, as well as the necessary foundation for additions of special knowledge. All that is herein included is meant to be contributory to that conception; bricks, as it were, in that foundation.

**Style.** — The manner of the book has been determined by a desire to make what is important seem interesting to young readers. If the author has been successful in what he has attempted, the intellectual effort per page needed to comprehend the text will be considerably less than if the book had been written with the idea of a formal text-book in mind. The teacher, in making assignments, should take this matter into consideration.

**Introduction.** — The introduction aims at appreciation. It rests on the principle of Herbart that "the pupil must know from the beginning what is aimed at if he is to employ his whole energy in the effort of learning." It is a frank attempt at motivation. It may be included or it may be omitted in the assignments. It falls into two parts. The first is devoted to appreciation of the subject matter to be studied; the second, to appreciation of the method of study to be used. The idea of this second part is to get
the student interested at the very outset in scientific
method, and to lead him to see that this method may be
of great value to him in life as well as in the laboratory.
Trial of this introduction has indicated that more of in-
terest and effort is aroused when such material is included
than when it is omitted. Many teachers have been inter-
viewed as to their opinion of such an introduction. It is
evident that the idea meets with approval, whatever opinion
may prove to be as to the manner in which it is carried
out in this book. If the introduction is used as lessons, it
should be used before laboratory work is begun.

Maintenance of Effort. — Just so far as is practicable,
the familiar always precedes the unfamiliar in the sequence
of topics. With a view to maintenance of effort as well as
of interest, the amount of "resistance" is gradually in-
creased as the reader progresses. Thus the technical
discussion of foods is postponed until Chapter IX, while
the non-seed plants, and the "hidden" parts of seed
plants, are discussed in the last two chapters. Yet these
two chapters, if what comes before is well understood,
need be no more difficult than the earlier chapters. Alter-
nation of generations and the morphological nature of
seeds are not topics intrinsically difficult. Only their
unfamiliarity makes them seem difficult. The exclusion
of these topics is warranted only by a teacher's inability
to present them clearly. Their inclusion is warranted by
their necessity to even the most elementary conception of
plant evolution, and by the need of them in any adequate
conception of seed plants themselves.

Plan of Presentation. — The plan of presentation is, in
a limited sense, spiral. Chapters I and II give a general
view of a seed plant as a whole. Chapters III to VIII
are devoted to an expanded treatment of what is briefly
touched on or suggested in the first two chapters. In Chapters IX and X the plant kingdom is considered in the evolutionary sequence.

The Questions and Suggestions which follow the chapters are of two kinds. Some are designed merely to serve as an aid in the study of the text, while others suggest study and inquiry outside of the text. Of this latter kind there are more than any one student is expected to cover. Selection will be made of such as are most suitable to local conditions.

Technical terms have been used only as real need for them has been developed. Upon first occurrence they are printed in italics.

Attention is called to the classified tables of terms which immediately precede the Index. These are designed to serve the student in review, and to be a general guide to the relative values of the facts presented.

Acknowledgments. — The sources of this book lie in modern botanical literature in general, but the chief source has been the Coulter, Barnes, and Cowles "Textbook of Botany." For spirit of treatment as well as for data, I am much in debt to Dr. Cowles's part of that work, the part on ecology. That work is also the chief source of the non-original illustrations used herein. The illustrations which are original are all the work of Miss Anna Hamilton. For critical reading of the manuscript I am gratefully and especially indebted to my father, Dr. John M. Coulter, to Dr. Cowles, and to Dr. Crocker.

JOHN G. COULTER.

BLOOMINGTON, I.L., July, 1913.
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PLANT LIFE AND PLANT USES

INTRODUCTION

PART I—PLANTS AND OURSELVES

1. Our Dependence upon Plants.—Plants are a part of life. Without them all life, our own included, would soon come to an end. Our lives depend upon their lives.

You are very much interested in life, but the importance of plants as a part of it may not have occurred to you. You know that food is one of the necessities of life, but you may not know that all food, directly or indirectly, comes from plants. You know that the country in summer is covered with plants. You know that their leaves hide the soil and make the hills and valleys green. But you may not know that green leaves are the food factories of the world.

When you eat an apple you are eating food that comes from a plant directly. When you eat an egg you are eating food that comes from plants indirectly. The hen which laid the egg lived on plants and on small animals which got their food from plants. All food comes thus from plants. Other living things can change foods from one kind to another, but only plants can change substances which are not food into substances which are food.

It is not for food alone that our lives depend upon the lives of plants. There are many other things which make them important to us. In this study you are to learn of
the important part which plants have in your own life, as well as of the nature of plant life itself.

Think of the many uses which we make of plants besides their use as food. From plants we get the principal material out of which homes are built, and it is plants that we use to beautify the grounds around our homes. When a man is able to make the sort of home he wants, he is sure to surround it with grass and trees, with flowers and shrubs. They seem a necessary part of the sort of home we all want. Think, too, of the use of plants for clothing. Cotton and linen are both made from materials taken from plants. Wool and silk come from animals which live on plants.

Food is the first need of man, and this need could not be supplied at all except for plants. Shelter and clothing come next in order of our needs, and for these too we depend very largely upon plants. Houses are for shelter, but they would be poor shelter in winter if they were not heated. Coal, wood, and gas are the substances principally used in producing heat, and all of these are derived from plants. Coal is composed of the transformed bodies of plants which lived many thousands of years ago, and gas is derived from coal. Even when we use electricity we are usually depending indirectly upon plants, for the power-houses which generate the electricity use steam engines, and coal is used to generate the steam. The steam engines, in turn, run the machines which generate the electricity. Think of all the factories, and locomotive engines, and steamships which also use coal. Evidently one of the principal uses of plants to man is that they provide him, or have provided him, with fuel. Gasoline has come to be one of the important kinds of fuel, especially in connection with automobiles. It is derived from petroleum, and petroleum, like
coal, was formed chiefly from the dead bodies of plants which were buried deep under the earth thousands of years ago. Lubricating oils are also derived from petroleum, while some oils, like cottonseed and linseed and castor oil, are derived from plants directly.

Wood is principally used in the building of houses and furniture, but there are other important uses of it. Think, for example, of the great quantities needed for telegraph and telephone poles, for railroad ties, and for fence posts.

Sometimes medicine is needed, and this need also is principally supplied by plants. Most of the drugs of which medicines are made are derived from plants. Rubber and gutta-percha, paper and perfumes, and many other much used substances are also derived from plants.

Each day you discover things which are new to you; things which make life seem to you more interesting and important. Just now you are to discover that knowledge of plant life will make your own life more interesting and more important. You are anxious to find out what you must know and what you must do in order to make your own life a success. The more you understand about life in general, the more likely you are to judge wisely for your own life in particular. To understand plant life and its relationships to human life will help you to understand your own life and its relations to the great world of which it is a part. You will learn that plants, besides furnishing food which makes life possible, may also furnish thoughts and feelings which make life pleasant; besides furnishing what is necessary to the development of our bodies, they may also furnish something needed for the development of our minds.
Plants are partners in life with us. They lived in the world before men lived in it, and they made the world habitable for men. The laws of life which control them are the laws of life which control us. To understand our own lives we must understand their lives. To understand their lives is to improve our own.

2. Our Enjoyment of Plants. — We enjoy the country chiefly because of the plants which cover it. We enjoy spring chiefly because then the grass turns green, flowers begin to bloom, leaves come out on the trees, and young plants grow up in the gardens. We may find it hard to explain this pleasure that we get from plants, but we feel it none the less. Something in us seems to respond to them. In fine weather we are glad to get out of the city, to go for a holiday into the country, to lie on the grass in the shade of trees, to look at what is green and growing.

The surface of the land is hidden by plants. They form the natural covering of the soil. Suppose you were up in an airship on a summer day. Green would be the color of the earth beneath you, the green of plants. The roads would make a few white lines across the green, and here and there you would see a house or catch a glimpse of a town. But nearly everywhere the earth's surface would be green, — green with the millions of plants which grow upon it. Of animal life hardly any evidence at all would be visible.

Suppose it was a July day and you were looking down upon farm lands in the Mississippi Valley. Corn fields would be below you, miles on miles of them, deep green and growing, shining in the sun. Here and there you would see fields of wheat and oats, pale green or turning yellow, through with their growth and ready for the harvest. In some fields you
View across a fertile valley in New York State.
would see men at work, the grain already piled in shocks. On hills and near streams you would see cattle grazing in the pastures, gathering their food from plants.

That great view of fertile country would delight you. Perhaps it would set you thinking. You might think of the miracle of nature by which this huge harvest has come from tiny seeds. You might think of the thousands of acres needed to yield food for one small city. You might think how small man is in the midst of the millions of plants which sustain him. You might think of the soil, that wonderful and complex layer which covers the rocks, and holds, firmly and nourishingly within itself, the roots of plants; it is of the soil we think when we say “Mother Earth,” for it is the soil which permits Earth to be “mother” of us all, plants and animals alike. As you looked down upon the great green carpet of plants below, you might remember that your own life depends upon this green life of plants, and perhaps you would feel grateful. At least you would enjoy its beauty, and might wish to know more about it.

Or suppose you were on a ship coming near to the steep shore of some tropical island. There you would see no sign of men, but high above you would stretch hill and mountain sides, covered with the deep green of tropical forests, only the bare white trunk of a tree showing here and there. All the land would be hidden, the year round it is hidden, under this heavy mantle of plant growth. Trees you would see everywhere, trees even growing out to sea, as is a habit of some trees in the tropics. Coming nearer, you might see little houses along the shore, but all the work of men would be a trifle compared with the mass of vegetation surrounding it. And so wherever you go in
Tropical vegetation. The U. S. Naval Station in Samoa. The harbor is an extinct crater.
the world, even to the very edge of the arctic circles, you will find plants in the growing season covering the earth with green, making it beautiful and fruitful, making it habitable for man.

Evidently plant life is one of the big things in the world in which you live. It is so big a thing and so important that you need to know about it. You need to know about it whatever your business is going to be. Even though you are not going to be a farmer, or a florist, or a forester, or in any other way make your living directly out of knowledge of plants, none the less it will pay you to have such knowledge. It will pay you to be able thereby better to appreciate the work of the farmer, who works for us all. Though knowledge of plants may not pay you in money, it will pay you in something else which is just as important as money. Money helps us enjoy life. Knowledge of plants may also help us enjoy life, and even more certainly than money does.

Every boy who likes to fish or swim or tramp through the woods is a lover of nature. Every girl who likes to gather flowers or watch the sunset is a lover of nature. All of us, whether we call it that or not, have some love of nature. It seems to be born in us. The pleasure that we take in plants is a part of it, a very considerable part of it. Nothing will more certainly add to our enjoyment of life than cultivation of this love of nature, and one way to cultivate it is to learn about nature. The more you know about nature (of which plants form such an important part) the more you care for the country. Knowledge of plants and animals makes it a different place for you from what it was before. With your eyes opened by knowledge, you can enjoy the country more than most people enjoy
the city. To those who are interested in nature and understand her ways, life in the country is the most agreeable of all kinds of life. The farm boy who learns the ways of plants and animals finds more to interest him on the farm than he does anywhere else.

So, through knowledge of plants, something may be gained which makes the world, wherever we go, a far more interesting place than it was before. We gain something that gives every acre of ground and every plant growing on it a new meaning for us. We gain something that makes us enjoy finding out the names and habits of all the plants we meet; we wish to become personally acquainted with them and to watch their changes through the seasons. We gain something that makes us see in a grove of trees or in a field of corn things that we did not see before — things that change the trees and the corn to us; we see them with new eyes; their growth and their behavior become matters of the greatest interest; we know that they have a history just as we have a history and that as we keep changing so they too keep changing. This something that we gain may be called appreciation of nature, and those who possess it are very fortunate, for there is nothing in the world that is more certain to make their lives enjoyable. They can find pleasure in watching even a dusty patch of weeds, while woods and fields have for them a meaning like fine music.

You yourself in your study of nature in school can begin to get this thing which we have called the appreciation of nature, and the sooner you get it the more it will be worth to you. It is one of the finest things in life, and the study of plants, if you are truly interested in them, can lead you straight to it.
3. **Plants in Spring.** — It is in spring that we wonder most about plants. Whether you go into fields and woods or stay in town, it is the same. You see things growing. You watch the trees and shrubs turn green. You see green things sprouting from the cold and seemingly lifeless ground. Sometimes you seem almost to feel things growing.

Who can see, day by day, this fresh color coming back into the trees and over the ground, and not find pleasure in it? Who can find the first violets, or see the first green coming among willows along brooksides, and feel no thrill?

Have you ever wondered how this plant awakening comes to pass? Have you ever felt that you would like to know the plants, somewhat as you know your friends, — know their names, know how they live, and know how man, whose life depends upon them, can, through knowledge, improve their beauty and their usefulness? Have you ever thought that when you come to travel or have days free for roaming in the fields and woods it would add much to your pleasure to know the trees and flowers you meet? Have you ever wished to be able to judge why plants grow in the manner and in the places that we find them? Have you ever thought you would be glad to know how best to beautify with grass and shrubs and trees your home, or the home that some day may be yours? Have you ever wished to have a garden or a farm of your own?

Have you ever suspected that the lives of plants are like our lives, at least in that they, too, must have food and air and water? Has it ever occurred to you that there is a kinship between all living things, both plants and animals, and that you, the most intelligent of all living things, should understand all you can about this kinship?
Have you ever felt, while things are growing about you, something in yourself that commands you to grow; something that makes you know that to grow you must have knowledge, just as plants to grow must have air and water; something that makes you hungry for learning just as you might be hungry for food?

It is quite possible that you do not recall having had such a feeling, and, even if you do, you may not see that it and the study of plants are connected. Indeed this very study of plants may seem to you now one of the dull things from which you would like to escape. But you may not be yet a fair judge of such things. Whether you see it or not, there is in the study of plants a chance to get the very thing you want most, yet hardly know you want. That thing is a large true view of life.

Two things are sure. One is that if you have not yet felt a "thirst for knowledge," then, sooner or later, more or less, you are going to feel it, for it comes to us all as surely as green sprouts come from good seeds. And the other is that the study of plants is necessary if we are to know about life. To learn of plant life is one way to gain an understanding of all life, and nothing is more important to us than that. For this, perhaps, you must take our word. We cannot prove it to you now. We can only promise it as one of the rewards of interest and of attention.

4. Plants and History. — We think of history as the record of mankind, a record of how cities and nations came to be what they are to-day. We do not find much in history about plants, yet plants have had a great deal to do with making cities and nations what they are. They
have had a great deal to do with making your own life what it is.

Plants make little stir in the world. They are silent. Where they grow, there they remain. Yet they have had even more to do with the making of history than kings and armies have had with all their wars and commotion. This is not just because men have depended upon plants for food and shelter and clothing; it is not just because the abundance of plants has made plenty, and the lack of plants has made famine. Even more than all that, it is because plants have changed. As men have changed, so plants too have changed. There is a history of plant life as well as a history of human life. These two histories have gone along together, and each has had a great effect upon the other.

The changes in plant life have been of two great kinds. First, there are those which have been caused by nature alone, and the history of these changes is a very ancient history. It is far older than the history of man; it runs down to to-day, and it is still going on. Men change from generation to generation, and so do plants.

The second great kind of changes in plants is found in those which have been wrought by man working with nature. The history of these changes is that of the cultivation of plants, and it is this kind of change which has had most to do with affecting human affairs. By means of cultivation the plants which now you see in the fields have been derived from ancestors which, in ancient days, grew wild upon the plains and in the forests. And in those ancient days our own ancestors roamed over the plains and through the forests. Civilization has made us very different from our savage forefathers. In like manner
cultivation has made the plants of the fields and of the orchards very different from those wild plants which once they resembled. It is this cultivation of plants which is so important a part of human history. This, more than anything else, has brought into the world such peace and prosperity as we have. This, more than anything else, has made man's life more than a mere struggle for existence. If the whole history of the cultivation of plants could be written, it would be a sort of history of man himself.

Some thousands of years ago all men lived a good deal as the Indians lived when Columbus discovered America. They were hunters and fishers. They roamed over the land. Their food came from the animals which they killed and from the wild fruit and roots which they gathered as they went about. The only advantage which they had over the wild beasts was that they had better brains. They learned to remember and they learned to reason. They learned which plants were good for food and which were not. They remembered when and where

A native home in the tropics. The buildings are composed entirely of materials obtained directly from plants which grow near by. In the foreground is a patch of taro, a plant whose underground parts are much used for food.
were to be found the fruits and roots which were good to eat. They learned that the plants which produced food would grow better if other plants around them were cut away, and probably this was their first step toward plant cultivation. They observed how plants reproduce themselves, and they began to clear the ground of useless plants and to save those which produced food. Thus the first little farms appeared.

Think how farming must have changed the life of our ancestors. It was foolish to plant crops and then go away and leave them. Those who planted began to wait for the harvest. Gradually they began to give up free roaming of the forests, and began to live near their little fields. They tended and guarded for the harvest which was to come. They began to make homes. They began to settle on the lands which were most fertile. They began to band

The coconut palm grows in almost all parts of the tropics. It is one of the most valuable plants in the world. No plant exceeds it in variety of uses. Food, oil, soap, rope, and building material are some of the things derived from it. It is also one of the most beautiful of plants.
together with their neighbors for mutual protection, and to help each other with the crops. Men living together form what we call society. Thus you can see the truth of the statement that "society grew out of waiting for the crops." It was plant life which made men cease their roaming and settle down. It was farming that created society, and it is farming that sustains it to-day. It was from farming principally that cities grew and nations arose.

Thus it is that the cultivation of plants has made our own lives what they are. It is the farmer, the man who works with plants, whose work is the most necessary of all. It is upon what he produces and does not use himself that all the rest of us live. It is the land and the plants which they bear which have made our history what it is, and they are to-day far more necessary to our existence than are cities and all the rest of civilization.

5. The Improvement of Crops. — After farming began, men learned how to improve their crops. They learned to do more than simply clear the land and plant. They learned to plow. They learned that the stirring of the soil improves the growth of plants upon it. They learned to save for seed the better ears of grain, and to transplant cuttings from the better vines and fruit trees. They learned to make the soil more fertile by putting certain substances upon it. They learned that it is best not to grow the same crop upon the same field season after season; that it is better to change in some seasons to other crops. They learned to cross one plant with another, and thus they produced new kinds which were of value. In these and in many other ways they improved their crops, and, as farming went on through some thousands of years, the
cultivated plants became more and more different from the wild plants which were their ancestors until now the fine fruits and grains are very different from those dwarfish forms from which they came. Yet even to-day the wild plant-ancestors survive. Even to-day a wild and hardy plant from which wheat was derived grows among the sterile hills of Palestine, while in tropical America thrives the ancient parent of the corn.

These are wonderful results which in the past have been attained in agriculture, yet even more wonderful results are being attained to-day. Agriculture has become a science. In the past men found that certain things they did to plants changed them; some of these changes were improvements, and so the crops were improved. Nowadays men are finding out more than that. They are finding out why plants change. They are learning just what to do in order to get the results they want. They are learning how to breed plants just as they have bred horses and cattle. They are finding just what to do in order to make the fields yield more than they did before, and they are finding how to make farm plants grow where they never grew before.

It is the knowing why as well as how that makes agriculture a science. Success in farming depends very much on
knowing why plants behave as they do; why the doing of certain things produces good results, and why the doing of other things produces poor results. Farms cannot be run best by rules alone. Each field is a problem in itself, and the farmer needs to know how to solve his problems for himself. To do this he must understand the principles of plant life. He must understand the conditions which are most favorable to plant growth, and learn to recognize what conditions are unfavorable to it. He must understand why it is that crop plants gradually poison the soil for themselves, and why it is an advantage to change the crops. He must understand why plants of the clover family increase the fertility of the soil, and why it is that deep plowing and frequent crumbling of the surface also increase it. He must understand the relation of water to plant life, and why drainage increases fertility. He must understand the principles which should guide him in
the choice of the seed which he plants. He must understand how to encourage that invisible plant life in the soil which helps his crops, and how to combat that parasitic plant life above the soil which injures his crops by causing crop diseases.

Such an understanding of plants is one of the necessary first steps in scientific agriculture, and it is also one of the principal things which this book seeks to give you.

**PART II — THE STUDY OF PLANTS**

6. **Reasons for It.** — You are entitled to know why you are to study this subject, just as you are entitled to know why you study any subject. Much of your time in the next few months is to be devoted to it. You have the right to know and should know why the study of plants is considered a good investment of this time. We are
usually careful to see that we get our money's worth, but it is even more important to make sure that we get our time's worth.

Your teacher is as much interested as you are in your understanding the reasons for studying plants. If you understand the aims of this course and keep them clearly in mind, you are certain to be interested in it. If you are interested, you are pretty sure to get your time's worth. If not, you are pretty sure to fail to get it. It is a simple matter. You must become interested if only to keep from wasting time, which is about the most valuable thing you possess.

So here are set down some of the reasons for studying about plants. Consider them carefully. If they seem to you good, the hours you spend should yield much profit. If they seem to you insufficient, there may be others which will appeal to you more. But by all means or by any means get interested if you possibly can, if only for the sake of getting a proper return for your precious time.

Reasons for studying plants:—

a. Because without plants we should all die. We depend upon them for food, for clothing, and for shelter. These are the three fundamental needs of life. Whoever is interested in life needs knowledge of the means which support life.

b. Because knowledge of plant life may help us keep well and prosperous; it may keep us from being sick or hungry. Even such a brief course as this will give you a chance to understand the principles of plant cultivation. This is the art upon which our food supply chiefly depends. Knowledge of its principles is necessary for good gardening or good farming. Certain very simple plants called bacteria
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affect our lives very much, both helpfully and harmfully. Some knowledge of them is highly important to enable us to avoid disease.

c. Because knowledge of plants may increase our enjoyment of beauty. This applies especially to the decoration of our homes. Knowledge about lawns and shade trees, shrubs and garden flowers, is almost sure to be of service to any one sooner or later.

d. Because in the study of plants we come to a better understanding of life as a whole. We find that the life of plants is in many respects like our own. We observe the working of laws which control our lives as well as theirs. We learn of facts which indicate that all life is constantly changing and being modified by new conditions. Plant behavior throws direct light upon what our own behavior should be.

e. Because (and this is very important) in the study of plants you may study the subject itself, and not merely what some one else has written about the subject in a book. This means that you must observe closely and do some reasoning for yourself. You cannot get your lessons about plants properly by memory alone, or by using some one else's formula in order to solve the problems. This method of study is not very important if you use it only to study plants, but it is very important and very valuable if you use it in solving many of the serious questions of life. It is called the scientific method.

These five reasons are by no means all the good reasons for studying plants. Very likely you can think of others for yourself; perhaps others may interest you more than these. If so, they are more important to you at present than the five which have been given. The important
thing just now is not what reason seems to you important, but that some reason seems to you important. Try to find some reason or reasons why the study of plants is important to you personally. Try to find a reason that makes you willing to do hard work in order to get from this study that which is important to you. Certainly there are such reasons. It is for you to find them out and apply them to yourself. If you can do this, the work is sure to be interesting and profitable. If you cannot do it, the work will probably seem difficult and tiresome. It is possible for each new exercise to be to you like a new scene in a play which pleases you. It is also possible for the whole course to be disagreeable. Which it is to be for you depends principally upon yourself.

7. Ways of doing It. — You will study about plants in two quite distinct ways. It is important to distinguish between them and to realize the value of each.

With one of these ways you are already familiar. It is the way in which you have already been doing most of your studying. It is the way in which you will learn most of the facts which you are expected to learn. When studying in this way about plants you do not learn from the plant itself, but you learn, from a book or from your teacher, what some one else has learned from the plant itself. This method is important because it is a great time saver, but to use this method alone would lead you to depend too much upon your books and teacher and too little on yourself. You must respect and use the knowledge of others, but you must also respect and use your own powers to gain knowledge for yourself; otherwise you lose them. This indirect method is called the didactic method.
(Didactic means that something is told, rather than learned by first-hand observation.)

In the other way you will learn but few of the facts you are expected to learn, but you will learn them from the plant itself, or from experiments which concern plants. This method is not important for the number of facts it teaches, but it is of great importance for the way in which it teaches them. It requires you to rely on yourself, to make your own observations, raise your own questions, and draw your own conclusions. This way of study makes you think for yourself. It keeps you from being a mere follower of some one else's thought. It requires you to use other powers than the power of memory alone. It requires you to get your information directly from the thing itself. This direct method of learning is what we have already called the scientific method.

In the preceding section you read something about this scientific method, but not enough. It is too important a matter to be dismissed with a few words, especially since it is a method which you may not have used in school before. If you do not realize at the outset its great importance to you, you may fail to put your best efforts into acquiring it and so miss one of the most valuable things which school can give you. Like all other really valuable things, this method of study and thought is not to be gained easily. It calls for the very best you can give of attention and of effort. You may have formed the habit of using little besides your memory in learning your lessons. It may seem strange and difficult at first to use this other method. But you can learn to use it. You are able to observe and to decide for yourself if you are willing to make the effort, and only by means of such efforts are strong minds developed.
Most of the facts about plants which you learn, unless you continue the study, you will presently forget. But if you learn this method once, and appreciate its importance, and practice it, you never will forget it. You will use it all your life. It will serve you best when you come to settle the most important questions of your life, it will lead you to the right answers in the great questions of behavior, and you will come to esteem it among your most precious possessions.

Knowledge changes as new facts are found, but this method does not change. It is one way to knowledge. Learning is knowledge of facts, but unless we know how to use the facts all our learning is of no more use than a dusty encyclopedia which is never taken off the shelf. Wisdom tells us how to recognize facts, how to understand them, and how to act in accord with them. Indeed wisdom is just this scientific method by another name. Though named with the name of science, this method applies to far more than just the things you think about when you say science. It applies to all the affairs of men. It is not a thing which concerns just astronomers and botanists and the like. It is a thing which concerns every man, and which is of as much importance to every man as it is to the scientist. It is called the scientific method only because it is through the study of science that man has developed it. It was by the study of stars and of plants, by working out the laws of life and of light, by seeking new knowledge in every field of nature — by such means the scientific method came to be what it is. It is more valuable to man than all his discoveries and achievements, for it is the method by which all the best of these discoveries and achievements were accomplished.
By means of it, in the yesterday of history, a few men discovered much to make us wonder. By means of it, in the to-day of history, many men are discovering much which makes us think and act. And by means of it, in the to-morrow of history, all men will learn to work together to make life best worth living.

8. Your First Plant Study. — Already you have had a good deal to do with plants. They have furnished you shelter and food and clothing. You have seen them alive and at work and have taken pleasure in their beauty. Consciously or unconsciously you have already acquired some miscellaneous knowledge about them. Presently you can begin to put that knowledge in order. Knowledge of plants put in order is the thing called botany. It is chiefly in books. Plants, however, live regardless of books and often break rules laid down for them.

Your first plant lesson is not concerned with botany or with books. It concerns only two living things, you and a plant. It is a little matter between yourselves. Let botany and books be for the time forgotten, but let your own good powers for getting information for yourself be well remembered. Perhaps those powers have been idle for a good while—idle in school, at least, where one can get along pretty well without using them. Now it is time to arouse them; to use them for all they are worth. Once aroused they will be worth far more to you than the power to learn lessons out of books. This is to be more than your first lesson with a plant. Possibly it is your first school lesson in getting knowledge for yourself—your first lesson in the scientific method.

In this lesson your teacher cannot help you much, must
not help you much. The important part of the lesson is what you find out for yourself. It may not be easy for you to find out things for yourself. You have been in the habit of finding things out in books. Now you must also learn how to find things out without books. You must use your own good powers of observation and of reasoning. Your brain may have formed the lazy habit of letting other brains think for it. It is time to make it begin to think for itself. Perhaps the best thing about the study of plants is that it does make you think for yourself, at least, it ought to, and this first lesson with a plant may be the most important lesson in your life. It may be your first lesson in using your brain for all it is worth, and not for only a part of what it is worth. For you it is a serious matter and calls for the best effort you know how to make.

Any plant will do for this first study. A plant, a piece of paper, and yourself awake, and we have materials for the first lesson which cannot be excelled. It is easy to supply the plant and paper. Any teacher can supply these, but no teacher can supply yourself awake. That rests with you. By yourself awake is meant awake in all your senses, attentive to the matter in hand, ready to appreciate its importance to you and to accept its invitation to self-improvement. You are to be an investigator, and the little plant before you is to be the subject of your investigation. The first step is to observe it carefully. Nothing makes us more sure to observe carefully than to draw the thing we are observing. So you are to make a careful outline drawing of this plant. Remember all the time that it is a living thing just as much as you are, and that each tiny part or position of a part may be important in this life you are investigating. Make a clear outline
drawing, showing each part in its natural position. While you are drawing, think of the life and growth of this plant; think of such questions about its life as you would ask it if it could answer. Your drawing is not to be shaded or indistinct, such as it might be in the art department. Each line is to stand for something you see, and everything you see is to have a line to stand for it — so far as that is possible. Draw as well as you can, but remember this is not an exercise in drawing. It is an exercise in observation and careful record.

When the outline is completed, you will record with words such of your observations as you could not record in the drawing. You have been observing carefully. Sight and feeling have both been working on this investigation. Few features of the structure or color or texture of that plant should have escaped your keen senses. You have noted also its general relations to its surroundings. You are now to make a list of these observations which will go along with the drawing to complete the record. The writing will help explain the drawing, and the drawing will help explain the writing. You made them for just the same purpose. They are to record your observations. Observations are worth little unless they are recorded.

With that finished, the questioning begins. You have made yourself think about that plant while you observed it closely. Your thoughts raise questions. You will not be satisfied now until some of your questions are answered, and it is just here that one of the most excellent characteristics of plant study appears. That excellent and to you most valuable characteristic is that for some of the questions you have raised you can find the answers for your-
self, not in a book, nor by any figuring process which some one else devised, but right here in nature, exactly as the pioneers of science discovered them. You are to play at being a pioneer of science yourself, and, if you play the game well, you can fairly feel the powers of your mind waking up and stirring within you. If you play the game well, you will let no one supply you with answers or explanations which you can find for yourself. That "finding for yourself" is the whole object of the game. To let some one else do this for you is as foolish as to steal a game from yourself. The object of any game is to try fairly to win. You win in this game, as in the game of life, by doing your own thinking. You lose in this game, as in the game of life, when you let other people do your thinking for you.

It is by such work in school as this work with plants that your powers to think are to be aroused. If you solve thoughtfully for yourself some little questions about plants, you may by the same method solve wisely for yourself some of the big questions of life. In this lesson it is not important that your solutions be right, but it is immensely important that they be your own and as right as you can make them. Observations and questions too must be your own; they are important even if you cannot find the answers.

So if you give your best efforts to this task and others like it, the powers of your mind will begin to work for you as perhaps you never knew they could work. "After all," you will begin to think, "this thing of solving real problems, especially the problem of my own living, is not going to be so very difficult, if I only have the sense to apply myself diligently to it. There's nothing to be afraid of except myself. I have the power to work independently and to
get results. The great thing is to keep that power at work. It is not at work whenever I let others do thinking for me that I should do for myself." You will go out from your study of plants, if you study them as we would have you, feeling new power growing within you. You have your own clear brain, and you are learning how to use it. It is the most valuable thing in the world when rightly used, and nobody has two.

But to go back to your questions. Dreams of power must never make us miss the next careful step. If we do miss it, we never shall reach our goal. Perhaps the little plant before you is a geranium in a pot. You will look it over. You will remember what you already know about it. You know that the parts you see are leaves and stems and that in the soil there are roots. What are they for? You know that plants grow, and hence you conclude that they are alive. What are the surroundings in which they will grow and what are those in which they will not grow? You know that living things require food. Where does the plant get its food? How does it grow? You know that this plant may presently produce a cluster of flowers. What are they for? You know that it reproduces itself. Though it dies, its kind does not die. Thus you already know that plants, like all other living things, have two great kinds of work to do. One is to keep themselves alive, the other is to keep their kind alive. One is nutrition, the other reproduction.

It seems fair and helpful to give you this much of a start. But now the suggestions stop, and you must go on alone. You will observe and draw the different parts of the plant. You will note other facts and other questions will occur to you. Your own common sense will help you
tell what questions are sensible and what are not. You will make a list of what seem to you sensible ones. Your teacher will discuss these lists, and select for your further study one or two questions whose answers it is quite possible for you yourself to find.

The first lesson now is over. The drawing and the writing are the only visible evidences of what you have done. But the most important part of the lesson is the invisible part, the part that goes on in your brain. However excellent the drawing and the writing may appear, the lesson is a failure unless this drawing and this writing have been produced by your brain alone. Have you borrowed ideas from any one else? Then, for your own sake, do the lesson over with some other plant.

It may be that your first plant study will not be the study of a whole plant. It may be the study of a part of a plant, such as a flower or a seed. But whatever the material used in this first study, whether it be the whole plant or only one part of it, the method of study you are to use is the same. It is the method which has just been described.

9. Later Studies. — Your first study will result in a collection of facts and of questions. Your later studies will result in explanations as well as in facts and questions.

As a part of your first study you are to prepare a list of questions. Those chosen from your list for further study may be like these: What is the work of roots? of stems? of leaves? A complete answer to any one of these questions has not been worked out by botanists themselves, yet the principal kinds of work done by roots and stems and leaves are not difficult for you to discover for yourself.
In seeking the answer to any one of these questions you are sure to meet facts which help supply the answers to the others. So it is well to have a number of questions in mind even when you are giving particular attention to one. You will not solve your problems one at a time. You will solve them together. That is because everything in life depends so much on everything else. All the parts of living things work together. They do not work independently. They help each other. Thus all plant work, as you have seen, may be divided into nutrition and reproduction. Roots, stems, and leaves are sure to be working together to accomplish these great common tasks. So in finding out what share a particular part has in the whole work, you are sure to have light thrown on what the other parts are doing. Similarly, for example, you may have studied an automobile engine. In studying one part, you learned something also about the other parts.

In trying to explain facts you have observed about plants, you will need advice on several points, and one principal point is this—avoid haste. Hasty thought may be worse than no thought at all, but clear thought is the secret of wisdom. You cannot think clearly of these matters and think in a hurry. Don’t let the idea bother you that some one else may find an explanation before you do. What you want to do is to forget everything but the problem. Forget even yourself. You are a true scientist only when you put yourself and your feelings entirely out of mind and consider the question only in the light of the facts.

Here is the plant body which grows. How do the materials which are added to it get into it? Certainly not through a mouth, as in animals. How then? Your own
clear thought working on facts you can observe will furnish you an explanation for this, but hasty thinking is almost sure to lead you into error.

Thinking attentively, you are almost sure to find some explanation of what you have observed. The next step is to test the explanation. See whether any other will do as well. For example, you might explain the refreshed look of plants after a rain by saying that the leaves absorb water as it falls on them. But another explanation of this fact will do as well, and other facts, discovered later, will show which is more nearly true.

New facts will constantly become your property as you proceed, and help you form explanations of such matters. Your later studies will thus be lessons in one of the great uses of facts — the use of them in forming explanations.

10. The Notebook. — The notebook is usually the most unpopular feature of high school botany; this is natural, since boys and girls of your age usually find writing and drawing tasks disagreeable.

Though the task may seem small and insignificant, to do your best is not small or insignificant, and to do less is to lose much, for it is to lose respect for the sincerity of your own effort. A sentiment like that might be useful on every page of a science notebook. Nothing in the whole course is better training for you than the keeping of the right sort of notebook, keeping it carefully, and keeping it up to date. It deserves your best efforts, and will reward them. It is the best device yet found for insuring careful observation and careful record, two things indispensable to science.

As to the drawing, against which so many rebel, you
will be interested in what was said by Huxley, one of the greatest of science teachers:—

In addition [to reading and writing] I should make it absolutely necessary for everybody, for a longer or shorter period, to learn to draw. Now, you may say, there are some people who cannot draw, however much they may be taught. I deny that in toto, because I never yet met with anybody who could not learn to write. Writing is a form of drawing; therefore if you give the same attention and trouble to drawing as you do to writing, depend upon it, there is nobody who cannot be made to draw, more or less well. Do not misapprehend me. I do not say for one moment you would make an artistic draughtsman. Artists are not made; they grow. You may improve the natural faculty in that direction, but you cannot make it; but you can teach simple drawing, and you will find it an implement of learning of extreme value. I do not think its value can be exaggerated, because it gives you the means of training the young in attention and accuracy, which are the two things in which all mankind are more deficient than in any other mental quality whatever. The whole of my life has been spent in trying to give my proper attention to things and to be accurate and I have not succeeded as well as I could wish; and other people, I am afraid, are not much more fortunate. You cannot begin this habit too early, and I consider there is nothing of so great a value as the habit of drawing to secure those two desirable ends.

Notes, to be of much value to you, must be original with you. They must be the record of your own thoughts and observation, not a record of the thoughts and observations of others. If the notebook is not largely original with you, the time spent upon it is largely wasted. Notes which are not original may be valuable memoranda, and good practice in handwriting, but they are not the kind that rouses the power of your brain.

The study of plants is in your course and the notebook is a part of that study largely in order to induce you to
do your own thinking. The structure and the behavior of plants you can observe for yourself. You can think about what you see, and you can write down your thoughts and observations in the notebook. Most of the important things, even in science, you will learn from books or from other people. You do not have time to find out very much for yourself. You must take "short-cuts" to knowledge. Yet it is of extreme importance that, with respect to a few things at least, you do find out for yourself. Your power to find out for yourself and to judge for yourself must be developed, for it is a power of which you will have great need. So, in the study of plants, you are to find some things out for yourself. You are to have an excellent opportunity to observe, to reason, and to come to conclusions. But all your observing and your thinking will be of much less value if you do not make careful record of it in a notebook. Thoughts come to us as we write them down, and they are of value only as we express them. Thus the notebook is an opportunity you must not neglect. If you force yourself to observe, and to think, and to record your observations and your thoughts, that work will put power into your brain as starch puts stiffening into a limp rag. If you neglect such an opportunity, you are in a fair way to have a limp-rag sort of brain all your days.

It is when you get to notebook work that you begin to get the most important results from your observations and your thought. Pen and paper are mechanical aids without which good thinking loses much of its value. It vanishes like a fog and is lost unless you make a record of it. Thinking is only a misty sort of thing at best until you set it down in black and white. Once you learn to do that, you have begun to realize on the product of your