

Botany: An Ecological Approach

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Preface

Botany is the scientific study of plants. But it is also men and ideas, facts and concepts, the search for truth, and the challenges and frustrations of unsolved problems. In short, it is a living science that is worthy of man's most serious intellectual efforts.

The first man who planted a seed with the hope that it would yield food—and wondered what he could do to help it grow—was a botanist. With the concept of cultivating plants came a dependence on plants that slowly developed into a modern social and economic order. But this dependence also brought the very real threat of famine, if the crop failed. It also brought another, rather ironic peril—a surplus of food that allows the human population to increase at such rates that no amount of cultivation will ultimately be able to feed man unless these rates are slowed.

But botany is more than the growing of crops and the fighting of crop disease. It is the joy of seeing spring flowers and knowing why they are growing in a particular spot and why they are blooming now. It is seeing plants, knowing their names, knowing where they come from, and knowing what they are used for. Above all, it is an increased awareness of the living world of plants that surrounds us and upon which we are dependent.

Ecology is the scientific study of plants and animals and their interrelationships with their environment. But it is also a unifying concept in biology that relates activities within an organism and between organisms. It is the science that answers the question: why does that plant grow there? It is also the science that relates growth to decay and photosynthesis to respiration. And it is now being called upon to unravel—and perhaps to remedy—the train of events initiated in the earth's ecosystem by man's activities. Obviously, ecology is related to botany, and we have therefore used it as the unifying theme in this book. But this is a botany book with an ecological approach—not an ecology text.

Anyone writing a book on a general topic like botany is faced with two problems—giving enough facts and ideas so that the field can be understood and, at the same time, presenting a broad overview so that

these facts can be pieced together into a meaningful whole. We have tried to do this by devoting Part 1 (consisting of two chapters) to a general introduction to the major areas of botany. We start this introduction by taking a walk in an acre of woodland, which leads us down through the layers of organization to the cellular and molecular levels. After this general introduction, we work our way through the cell in more detail (Part 2) and then cover genetics and evolution (Part 3). Using this as a base, we begin a second examination of the plant kingdom, covering the viruses, bacteria, algae, and fungi in Part 4 and the land plants in Part 5. The physiology and development of vascular plants is discussed in Part 6. Finally, in Part 7 we deal with land-plant ecology, which in a sense completes the cycle and returns us to the first chapter. By using this approach, we hope that the general aspects of botany will be apparent at the beginning so that later the detailed material will be more interesting and more meaningful. Throughout all these chapters, the thread of ecology serves as our unifying factor.

We also believe that a textbook like this should clearly indicate which material is basic to an understanding of botany and which material is essentially enrichment material that extends both the level and the interest of the primary text. Our response to this need has been to organize the chapters into four main sections: photo essays, core text, essays, and end papers. The core text focuses on primary aspects of botany, and the enrichment materials (photo essays, essays, and end papers) provide both a more detailed examination of certain topics mentioned in the text and interesting discussions that relate botany to the world around us.

Most chapters begin with a photo essay. Thus a photo essay may be a pictorial introduction to marine algae or ferns, or it may be a look into a herbarium or a biochemistry laboratory. In either case, it sets the scene for the chapter.

The chapter proper—what we think of as the core text—is written in an easy-to-read, narrative style and has an introduction calculated to arouse and hold your interest. In the core itself we stress the basic and essen-

tial elements of the subject being discussed. Wherever possible an ecological approach has been used; for example, in the two chapters on algae, the environment in which they live is related to their morphology and life cycles. We have also stressed the relation of form and function; our discussions of photosynthesis and chloroplasts and mitochondria and respiration are good examples. Finally, wherever it has been possible in the core text, we have introduced information and examples relevant to current problems and man's role in the ecosystem.

Within the chapters—but separate from the text—are the essays, which cover a wide range of topics and serve several functions. Sometimes, they expand upon certain topics covered in the core text by presenting additional material in greater detail. They also introduce interesting and relevant asides, such as recipes for making yogurt and sushi, directions for growing bonsai trees, an account of Lord Kelvin's disagreement with Darwin about the age of the earth, and a discussion of enzyme detergents. Another important function of the essays is related to the way in which science operates. We know that botany is more than facts, and we have tried to emphasize this by examining the evolution of important concepts and the men behind them. But we have gone one step further—we have let botanists speak for themselves! We wrote to several dozen friends and colleagues asking them to tell us about their work and about themselves. In return, we received a fascinating collection of letters that provide an insight

into not only how an idea is developed in the laboratory but also why these scientists became botanists.

Many chapters have end papers that are either an extension of the core material or additional background material related to the chapter itself. For example, Chapter 9 covers mitosis and meiosis and has an end paper on the ultrastructure of cell division; Chapter 6 discusses photosynthesis and chloroplasts and has an end paper on light; Chapter 19, which includes the water molds, has an end paper on sex hormones in fungi; and Chapter 29, which details angiosperm systematics, has an end paper on the evolution of systems of classification. End papers allow the student to pursue some topics in greater depth, and they can also be used as topics for class discussions, since they often present both sides of a controversial problem. You can take or leave the essays and end papers—but we bet that you'll both read and enjoy them!

Finally there is the matter of the index and the glossary. We present no formal glossary as we feel that a term defined out of context is frequently confusing. Instead of a glossary we have indicated in the index through the use of boldface type the page on which a term is defined. On that page the term is underlined and its meaning is given. This procedure has also allowed us to deal with many more terms than space in a formal glossary would allow. Numbers in the index that are in italics refer to pages on which the subject is illustrated.

Well, here it is—our approach to a botany text!

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Botany: An Ecological Approach

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1

Ecological Botany

An Acre of Woodland

A woodland, where moisture is abundant, is a marvelous place to be introduced to plants. In an acre of woodland, which might include a stream or a pond, we can find representatives of most major plant groups. Of course, not all woodlands are the same, and the types of trees and other plants present will vary, depending upon climate, soil, past history, and many other factors.

A For this introduction to the world of plants we have chosen an eastern beech-maple forest in Michigan. Such forests, covering extensive areas of the United States, should be familiar to many of you. This photo shows the most common trees found in our forest: the smooth-barked beech (*Fagus grandifolia*) and the sugar maple (*Acer saccharum*). These trees lose their leaves in the fall and are therefore called deciduous. During the summer the floor of our forest is heavily shaded, except for flecks of sun.

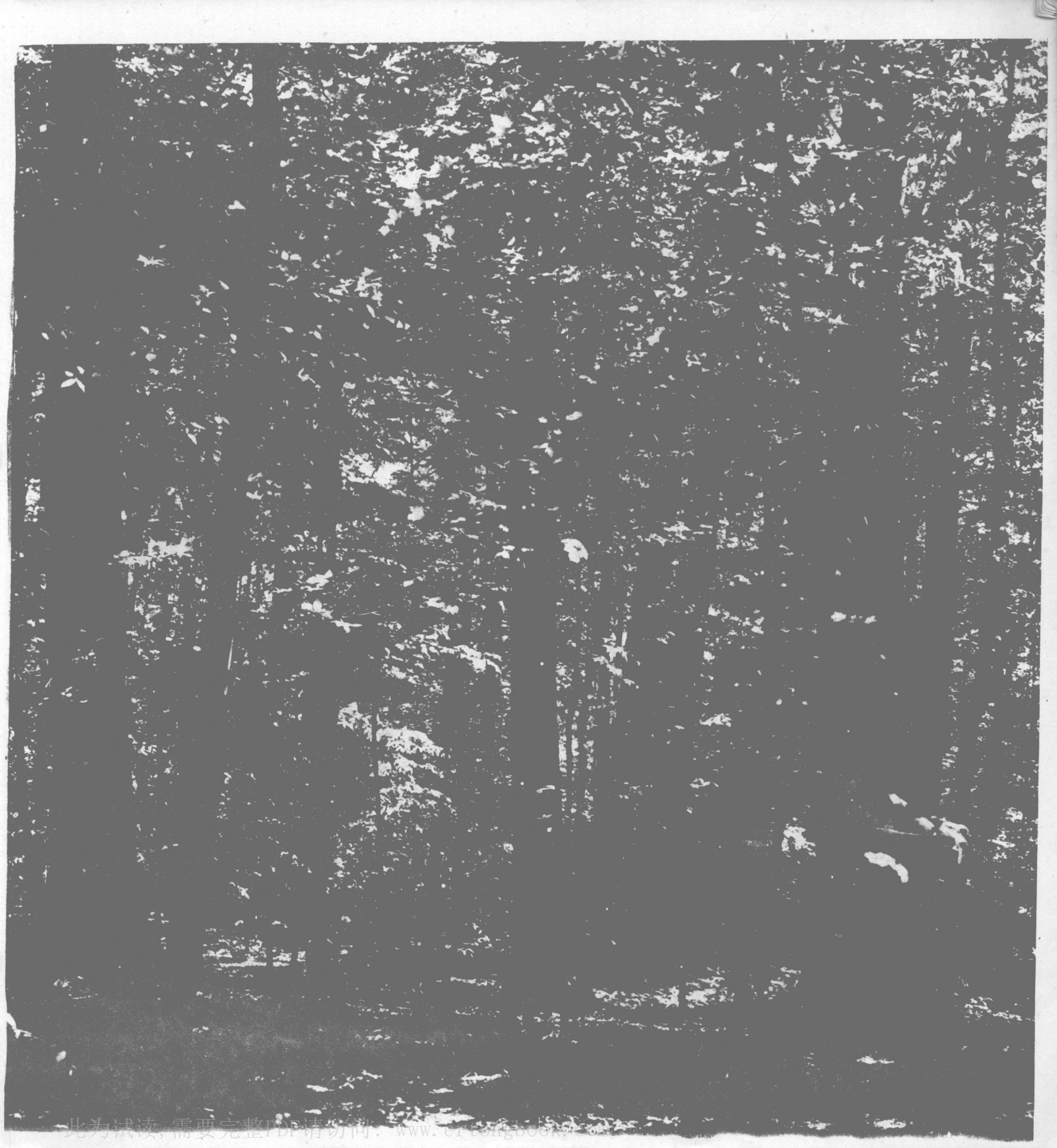
B But our woodland acre consists of more than trees, and among the other plants found growing here are the various shrubs. These form an intermediate stratum in the forest, as this flowering dogwood (*Cornus florida*) shows. Shrubs are particularly common near edges or openings in the forest, along roads, and near streams and ponds.

C A shrub commonly found in deciduous forests in the East and in streamside forests in the West is this chokecherry (*Prunus virginiana*), whose flower and foliage are shown in this photo.

D On the forest floor we find still another layer of plants. Many of these, unlike the trees and shrubs, live for only one year, growing from seed to maturity and death in a few weeks or months. A common species found in our particular woodland is the wild strawberry (*Fragaria virginiana*). The strawberry is also an example of a large group of plants known as dicotyledons or dicots for short. Among the distinguishing characteristics of these plants are their relatively broad leaves with net veins and seeds with two special food-storage leaves.

E We can also find various species of grasses, such as this *Panicum*, on the forest floor. The veins in the leaves of these plants are parallel and therefore help to identify them as members of the second great group of flowering plants known as the monocotyledons or monocots.

F Some of the flowers growing on the floor of the forest will be found only at the edges of our woodland, while others can grow in the deep shade cast by the trees and shrubs. This is true of the sweet william (*Phlox divaricata*), common throughout the eastern United States.





B



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E



F

G In our woodland some species of plants are easily recognized because they are so common, while others are rarely seen—and then only by those who know where to look. Both types are shown in this photograph. The rare plant on the right is the beautiful lady's slipper orchid (*Cypripedium calceolus*). On the left is the common poison ivy (*Rhus toxicodendron*), with its characteristic pattern of leaves in a group of three. Anyone who frequently walks in woodlands should learn to recognize this unpleasant member of the flora!

H Many woodlands contain swampy regions, and our acre is no exception. A variety of plants grow around and in such wet areas, and a few live floating on the surface of the water. One such plant is duckweed (*Lemna* sp.), a minute flowering plant, far smaller than the maple seeds shown floating next to them.

I Flowering plants are not the only inhabitants of our woodland. Ferns are important members of the flora in many forests. These plants, which lack flowers and seeds, must reproduce through the production of spores.

J Another spore-producing plant found in our forest is this horsetail or scouring rush (*Equisetum arvense*). This plant has two kinds of branches: the highly branched, vegetative kind on the left and the reproductive kind on the right. The reproductive branch has a cone at its tip and leaves greatly reduced in size.

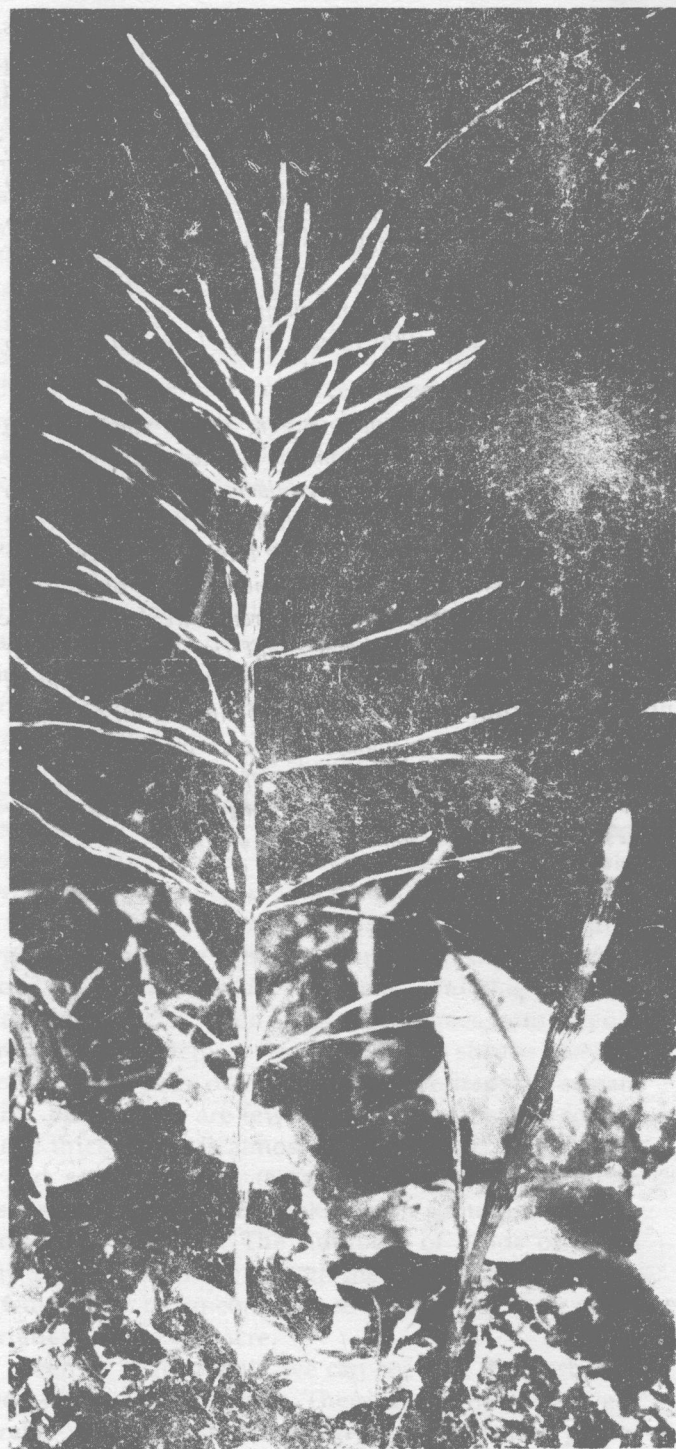




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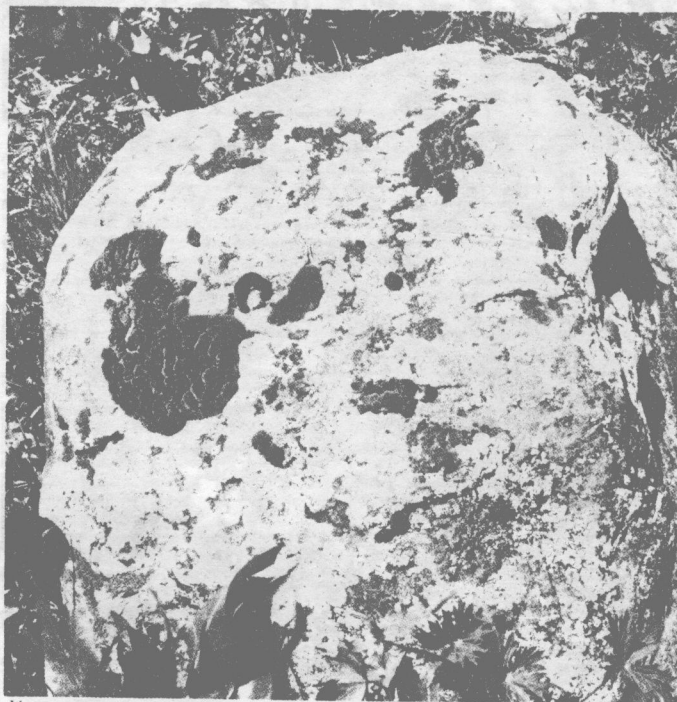
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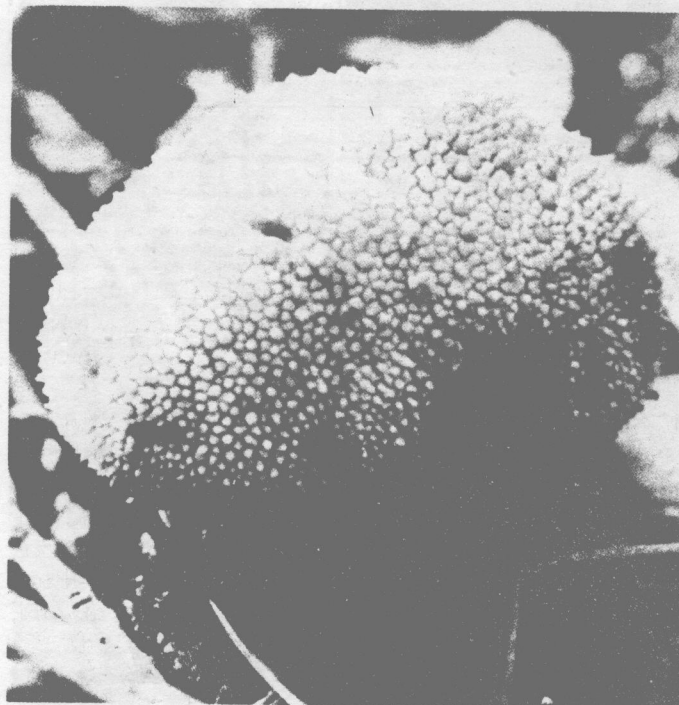
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K Mosses are another flowerless group of plants frequently found in woodland acres across the continent. They can grow in many parts of the forest, but here we find them on the surface of a rock. The thick clumps of moss are the dark patches, which appear cracked and dead because the weather has been dry for some time. Following the next rainstorm, they will become green again and begin to grow. Also growing on the rock are numerous, much lighter colored plants called lichens. These are an unusual combination of two quite different plants, growing together in such close association that they actually form a new group of plants.

L Life in our woodland acre is not simply those plants that we see growing from the surface of the soil. The soil itself is a living mat of organisms that are critical to the life of the forest. Algae, bacteria, and fungi all inhabit the soil, but most of the time we are unaware that they are there. Under certain conditions some of these organisms, like the fungi, become readily apparent. We see them because they form fruiting bodies that rise from the forest floor in the shape of the familiar mushroom. Each species produces a distinct type of fruiting body, not all of which resemble the common toadstool. Here, we see a small, spherical fruiting body of a group of fungi known as the puffballs, so-named because when mature they release their spores in a puff when someone steps on them!



K



L

We human beings are curious creatures. We search for understanding of our universe, our world, and ourselves. Botany is one small but important part of that search. It is concerned with the plants upon which the existence of man—and all other animals—depends. Although this quest has been conducted casually from the beginnings of mankind, during the last 250 years it has evolved into an intensive study. Because of its intensity, its formalized methods, its organization of knowledge, and its special tools, we now call our search a science, the science of botany.

The first two chapters will introduce this search and some of its results. We will survey the entire field, partially to introduce some important concepts to be used as building blocks in subsequent chapters. For example, the orientation of this book is ecological; yet ecology is such an all-encompassing science that its detailed discussion must be postponed until basic terms and ideas have been presented. Although some new terms are defined immediately (most are discussed and defined in later chapters), we have generally avoided this practice, believing that it is distracting and that most terms will already be somewhat familiar.

An Acre of Woodland

Let us begin our search of the plant world by visiting a patch of woodland, perhaps an acre or two, preferably with a small clearing and a stream meandering through one corner. This is a good place to begin not only because so much of the plant world is represented but also because woodlands, whether they are natural or planted by man, are readily accessible to almost everyone. Much of our present civilization developed in forested areas, and man seems to enjoy the presence of trees in his environment. Often, he clears the forest for his grassland crops, wheat and corn, but when he breaks the treeless prairie sod to plant these same crops or to build cities, he also plants trees around his dwellings and in parks. Even in the desert, he plants trees and waters them, making his own acre of woodland. Our mental visit to a representative woodland will emphasize (but not exclusively) the kind of forest that one might encounter in much of the eastern United States or western Europe—the great deciduous forest.

In the forest we are in a world dominated by plants, where trees are the overwhelming aspect. In much of the temperate zone, the trees are deciduous, providing an appearance of dense foliage during the warm months and barren twigs the rest of the year. There will probably be maples, elms, and numerous others such as oaks, sycamores, ashes, willows, and birches. Wherever Western man has extended his civilization, he has planted these species, as well as the conifers (spruces, firs, and pines) of western Europe. Of course, in his travels he has encountered and put to use a host of other deciduous and evergreen species: cottonwoods, aspens, Douglas firs, sugar pines, loblolly pines, sequoias, and eucalyptuses. Many western or southern woodlands might consist primarily of these species. In the tropics and subtropics, our woodland might contain such broadleaved, evergreen trees as the pepper tree, the camphor tree, and many of the acacias. Most of the trees fall readily into two groups: the broadleaved, deciduous trees that are really flowering plants and the needleleaved, evergreen trees without true flowers. There are a few interesting exceptions that we shall encounter later.

Next to the trees, the shrubs are most conspicuous. Again, the variety is tremendous, probably even greater than the variety of trees. In temperate climates the dogwoods, serviceberries, willows, raspberries, thimbleberries, and most others will be deciduous. A few such as the holly, the Oregon grape (a Western plant hardly large enough to be called a shrub), and the rhododendrons are broadleaved evergreens, and the yew is a needleleaved, evergreen shrub. If the trees form a dense canopy in our acre of woodland, the shrubs may be limited to the edge of the clearing or perhaps the stream bank, but if there are few trees, the shrubs may form a dense thicket that is almost impenetrable.

To see the herbs (smaller, nonwoody plants) in their splendor, we must make a visit some time during spring and summer. The numbers of kinds of herbs may well exceed those of both the trees and the shrubs. It would not be uncommon to find 20 to 50 or more varieties within our acre.

Even in a short visit, we can see that the herbs fall into two general categories. There are the narrowleaved, parallel-veined grasses in the group of flowering plants called monocots. Lilies, iris, jack-in-the-pulpit (al-