HAUPT

Introduction to BOTANY

McGRAW-HILL PUBLICATIONS IN
THE BOTANICAL SCIENCES

Edmund W. Sinnott, *Consulting Editor*

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Preface

The purpose of this book is defined by its title. It is intended to introduce the college student to the science of plant life. It aims to present clearly and concisely such basic facts and principles concerning plants as are essential to an understanding of their structure, functions, life relations, and evolution. It does not attempt to cover the subject in an exhaustive way, but to furnish a foundation upon which more advanced studies may be based. By presenting fundamentals, an opportunity is provided for the teacher to elaborate upon whatever topics he may desire. No textbook, however comprehensive or skillfully written, can take the place of a good teacher. Although the book is adapted to a one-semester course, more material is included than ordinarily can be covered in a single semester. Certain portions may be omitted, however, without affecting the continuity of the whole.

An effort has been made to achieve a well-balanced treatment. Whatever emphasis is placed on morphology is justified by the conviction that the study of structure is fundamental to a proper understanding of all other aspects of botany. Because structure has significance mainly in terms of function, the principal physiological processes are given considerable attention, stress being placed on the concept of the plant as a living thing. The structure and functions of the vegetative organs of seed plants precede an account of the organs concerned with reproduction and dispersal. Environmental relations form the subject of one chapter, heredity and plant breeding of another. The chapter on principles and theories of evolution now follows the discussion of heredity instead of coming at the end of the book, as in the previous editions. This is followed by a survey of the plant kingdom, comprising six chapters, which, in the customary way, is presented by a series of forms of gradually increasing complexity. The book ends with a chapter on the plant life of the past.

Because of their general biological interest, especially to the student who does not pursue his biological studies beyond the elementary

course, special attention is given to such topics as metabolism, insectivorous plants, pollination, parasitism, heredity, and evolution.

In Part One, metabolism is now the subject of an entire chapter, which contains much new material. The discussion of photosynthesis has been brought up to date, and an account of vitamins has been added. The topic of irritability is now included in a new chapter on growth and movement, which also includes a consideration of turgor movements, plant hormones, polarity, and photoperiodism. The chapter on heredity has been entirely rewritten and rearranged. In Part Two, dealing with the evolution of the plant kingdom, descriptions of *Chlamydomonas*, *Nemalion*, *Polysiphonia*, *Aspergillus*, and *Penicillium* have been added, the cycads and *Ginkgo* have received fuller treatment, and a comparison between the newer and older systems of classifying the vascular plants has been included.

The introduction of new material has not materially increased the size of the book, for, in the interests of clarity and simplification of expression, the discussion of many topics has been somewhat condensed. It is hoped that the inclusion of a glossary will prove helpful to the student. The book contains a number of new illustrations, some of which are taken from the author's recent "Plant Morphology," while many of the old illustrations have been replaced by improved ones. As in the previous editions, the great majority of illustrations are original.

The author wishes to express his appreciation of the interest indicated by the widespread adoption of the earlier editions and hopes that the book in its present form may be received as cordially Suggestions and criticisms will be welcome.

Arthur W. Haupt

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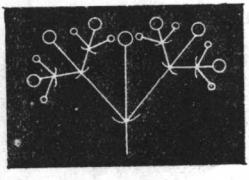
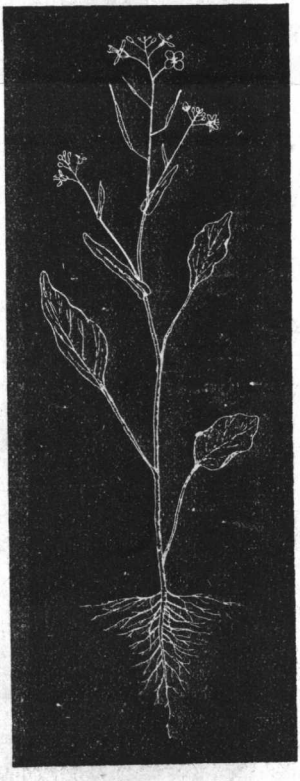
PART ONE

The Structure, Functions, and Life Relations of Seed Plants





1 *Introduction*

Botany is the science of plant life. It treats of the structure and functions of individual plants, their relations to the environment, and their relations to one another as members of the plant kingdom developed through the ages by the natural process of evolution. Together with zoology, the science of animal life, it makes up the larger field of biology, the branch of knowledge that deals with living things in general and with the processes of life in all their varied and complex manifestations. Plants and animals possess a characteristic bodily organization that at once sets them off from minerals, rocks, and other lifeless things. For this reason they are called *organisms*. The type of organization differs in the lower and higher forms of life. Nevertheless, all plants and animals, whether simple or complex, are organisms, and all substances, processes, and laws peculiar to them are said to be organic.

Although the animate is sharply set off from the inanimate, it is not always possible to distinguish between the two forms in which life commonly exists. Distinctions between typical plants and animals are rather easily made, but these break down when certain lower forms of life are examined. Because of the existence of organisms intermediate in certain respects between plants and animals, all living things cannot be separated into two conventional groups. And because even the most highly developed plants and animals have many fundamental features in common, it is no exaggeration to say that all life is one.

Features Common to Plants and Animals. The distinction between living and nonliving things rests upon certain basic similarities in organization and behavior shared by all organisms. These may be briefly stated as follows: (1) Life is always associated with a unique substance, called *protoplasm*, of which the bodies of all plants and animals are composed. (2) This living matter is organized in both plants and animals into microscopic units called *cells*. (3) Certain vital processes, collectively known as *metabolism*, take place in plant bodies

in substantially the same manner as in animal bodies. These include digestion, absorption, assimilation, and respiration. (4) The property of *irritability*, which is the power of responding in a definite way to external influences, is common to all living things. (5) Growth in all many-celled organisms takes place by a complicated process of cell division followed by cell enlargement and cell differentiation. (6) The essential features of reproduction are common to plants and animals. (7) The same natural laws, such as those of heredity and evolution, apply to all organisms.

Distinctive Features of Plants. The concept of the essential unity of life is based on the existence of certain lower organisms intermediate between plants and animals and on the occurrence of fundamental features common to all organisms. Yet, when a comparison is made between a typical plant and a typical animal, many differences are at once apparent. Plants are stationary, sending roots into the ground and leafy stems into the air. They absorb from the environment certain simple inorganic substances and from them construct complex foods under the influence of sunlight. This is a function of all green plants and one that animals do not have. Consequently all animals are entirely dependent upon an external source of nourishment, upon food originally made by green plants. Plants without green coloring matter are like animals in this respect.

In order to obtain food, most animals move freely from place to place, an ability that they share with only a very few of the lower plants. Animals exhibit a high degree of sensitivity, whereas plants respond slowly to external influences. On the other hand, such animals as sponges have no power of locomotion and are very sluggish in their responses, while the leaflets of the sensitive plant close together almost instantly when touched (Fig. 1). The stationary habit of plants is correlated with their more rigid tissues, the power of rapid movement in animals with their softer tissues. Most plants are freely branched and have a loose, open form. Their stem tips grow in length throughout the life of the plant and continue to produce new organs. Animals have a compact form, grow only during early life, and have but one set of organs.

When the differences between plants and animals are carefully considered, it can be seen that all differences rest upon one primary distinction—the ability of green plants to make their own food. With this single exception, dependent plants show all the other features

which distinguish plants from animals, because they are descended from plants that were originally green but gradually lost the ability to manufacture food.

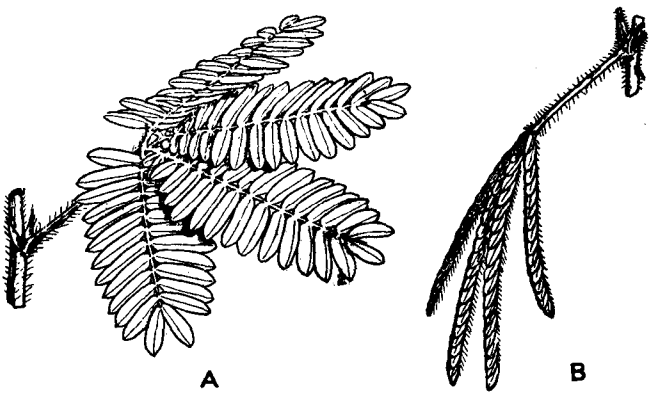


FIG. 1. Leaf of sensitive plant (*Mimosa pudica*) in open (*A*) and closed (*B*) conditions. Upon being touched, the entire leaf droops and the leaflets close tightly together. (*After Duchartre.*)

Scope of Botany. Plants may be studied from a number of different aspects, each of which has been organized as a special phase of botany. This has been made necessary for purposes of advanced study because botany has become too vast a subject to be mastered in its entirety by any one man. Naturally, in an introductory course in general botany, emphasis must be placed on the more basic divisions of the subject, as these form the foundation upon which all advanced studies rest.

Morphology, the study of the form and structure of plants, is the most fundamental division of botany. It includes a consideration of gross features as well as minute details visible only under the microscope. Some phases of morphology are known as "anatomy" and "histology," but these terms are rather loosely used. The special study of the cell, the unit of structure, is called *cytology*.

Physiology deals with functions—with vital processes and activities. A study of the functions concerned with metabolism, irritability, growth, and reproduction belongs to the field of physiology. These it seeks to explain, as far as possible, in terms of physics and chemistry. Since the behavior of organisms depends upon their structure, a general knowledge of morphology is necessary to a proper understanding of physiology.

Taxonomy, concerned with the naming and classification of plants, is the oldest branch of botany. Plants and animals are named according to a binomial system devised by the great Swedish naturalist, Carl von Linné, more commonly known as Linnaeus (Fig. 2). Every known species of plant has been given a scientific name consisting of two parts. For example, the white oak is *Quercus alba*, the common potato, *Solanum tuberosum*, the red clover, *Trifolium pratense*, etc. Plants are classified into groups on the basis of fundamental structural resemblance, which indicates natural relationship.

FIG. 2. Carl von Linné, 1707–1778.

Morphology, physiology, and taxonomy are generally recognized as the three basic divisions of botany, but other more specialized branches of the science are important and should be given at least brief consideration in an elementary course. *Ecology*, a more recent field of botany, takes up the environmental relations of plants—their relations to one another as members of plant communities, and to the various factors of their physical environment, such as soil, light, moisture, and temperature. All living things are adapted to the conditions under which they live. *Plant geography* deals with the distribution of plants over the surface of the earth and with the factors responsible for it. *Paleobotany* is concerned with the distribution of plants in time. It deals with the history of plant life as revealed by a study of fossil remains. Numerous facts, derived chiefly from a study of morphology and paleobotany, have demonstrated that the plant kingdom has developed on the earth by a gradual process of evolution.

In an effort to discover the causes responsible for the development of racial characters by evolution, a study of the origin of individual characters by heredity has resulted in the establishment of *genetics*. This subject is concerned with the differences and resemblances among individuals, especially those due to heredity. From a practical stand-

point, genetics is of great value in its application to plant breeding, which is the development of improved races of cultivated plants. Another field of great economic importance is *phytopathology*, dealing with the diseases of plants. These are caused chiefly by parasitic bacteria and other fungi. A pathologist must have knowledge both of the parasites and of the plants they attack. Scientific knowledge relating to plants useful to man is called *economic botany*. It underlies the practical handling of plants in cultivation and their utilization for human needs. Although the art of growing plants is older than any science, modern agriculture is based largely on the principles of botany and other sciences.

Some people think that only plants useful to man are worthy of study and that only knowledge pertaining to useful plants is valuable. This idea is fundamentally wrong, because a general knowledge of plants must be obtained before it can be applied to problems dealing with specific plants. Modern botany has developed largely through extensive investigations on plants of no direct practical value, but it is upon this knowledge that practical applications must rest. All botanical knowledge is useful whether or not it pertains directly to economic plants.

Importance of Botany. The science of plant life is studied for a number of important reasons, among which may be mentioned the following: (1) It is pursued for intellectual gratification. From a purely cultural standpoint, botany is of considerable value in giving one an acquaintance with the natural vegetation of the world, an enhanced enjoyment of the beauty of flowers and of ornamental plants, an appreciation of the phenomena of life, and an understanding of some of the great laws and processes of nature. (2) Botany is a necessary prerequisite to further studies. There are many fields of knowledge that are based largely or at least to some extent upon botanical facts and principles and for which an elementary training in botany is either necessary or desirable. These include agriculture, horticulture, forestry, landscape gardening, home economics, bacteriology, zoology, pharmacology, and medicine. (3) Plants make possible all life on the earth. Because green plants have the unique power of manufacturing food from certain simple inorganic substances through the energy of sunlight, they furnish a supply of nourishment not only for themselves but for all other organisms. All animals, including man, derive their