

# *Pharmaceutical* *Botany*

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Seventh Edition

1951

## *Preface to the Seventh Edition*

SINCE THE preparation of the Sixth Edition, marked progress has occurred in various fields of botany, particularly in plant anatomy, physiology, pathology, taxonomy, and economic botany. Some newer and better techniques have been devised for the preparation of plant materials for class work and investigation, and an increased and revised terminology has evolved as a result of this progress.

These advances necessitated some change in the text, although the general plan has been retained. The book is intended primarily as a textbook and secondarily as a reference. It has been thoroughly revised from cover to cover.

In the previous edition the author had broadened the scope of earlier editions of "Pharmaceutical Botany" through the introduction of additional general basic botanical principles so as to meet the needs of some courses in General Botany in universities and colleges where students of Pharmacy and Liberal Arts alike take the same course in General Botany. In the preparation of the new Seventh Edition the author has further increased the material in general botany without reducing the pharmaco-botanical subject matter of former editions.

In broadening the scope of this revision, the sequence of some of the chapters has been changed with a view of leading students gradually from the simpler and less technical to the more advanced aspects of botanical science.

Many portions of the text have been rewritten, a number of the old cuts have been removed and replaced by better ones, and the total number of illustrations has been increased.

Additional material on plant physiology has been introduced, including a new chapter on Metabolism which follows the chapters on the vegetative organs. A new chapter on Plant Environment has been introduced following Chapter 11, "The Seed." This reorganized chapter replaces the old chapter "Ecology" of former editions.

The chapters on "Plant Tissues" and "Non-protoplasmic Cell Contents" of previous editions have been brought up-to-date by the addition of new subject matter on meristems, phloem, xylem, vascular rays, plant hormones, synthetic chemical growth regulators, and vitamins. In this new edition these two old chapters have been combined into one chapter called "Plant Anatomy." This chapter should

PREFACE TO THE SEVENTH EDITION

provide sufficient material for a one-semester course following General Botany.

The Life History of the Male Fern, an intermediate type of plant, has been transferred from Chapter IV of the Sixth Edition to Chapter 20, "The Pteridophytes," and is placed after the Orders of Ferns.

Chapter 15, "Classification and Naming of Plants," contains additional taxonomic information including both the traditional and the newer systems of classification of the plant kingdom. Following chapters dealing with the various taxonomic groups and important economic subgroups contain descriptions of the drug-yielding plant families and tables of alphabetically arranged names of drugs yielded by them, accompanied by the botanical names and habitats of the plants from which they are derived.

Appendix II has been enlarged to include newer reagents, stains, and formulas for their preparation and, in addition, a number of modern methods employed in plant microtechnic.

The Glossary and Classified List of Reference Works have been retained and slightly enlarged.

The author desires to express his appreciation to Drs. M. W. Quimby and R. W. Vander Wyk of his department at the college and to Dr. A. F. Hill of the Botanical Museum of Harvard University for the helpful suggestions given him during the preparation of portions of the manuscript. Grateful acknowledgment is made to the authors, editors, and publishers of works from whom permission was cheerfully granted to use a number of illustrations in this edition.

Finally, the author wishes to express his gratitude to The Blakiston Company, whose Editorial and Production Departments gave splendid coöperation during the period of revision.

HEBER W. YOUNGKEN

BOSTON, MASSACHUSETTS,  
*September 1950*

## *Preface to the Sixth Edition*

Since the last edition of "Pharmaceutical Botany" was published, knowledge in plant science has advanced rapidly and a new edition of the United States Pharmacopœia and of the National Formulary have appeared. For these reasons another revision has been called for.

In preparing this revision the writer has endeavored to keep in mind the requirements of varied courses in botany given to students of pharmacy in departments of botany of both the university schools and the independent pharmaceutical institutions. In both types of schools botany should be taught with cultural and professional objectives, and the pharmacy students provided with the proper pharmaceutical slant which need not detract from adequate treatment of the purely academic phases of the subject.

A revision has, accordingly, been prepared which presents a broad general treatment of botany with particular stress upon those phases of this science such as histology, cell contents, taxonomy, and medicinal plants which are believed to be most helpful in preparing students to cope with botanical problems in pharmacognosy and in the practice of pharmacy.

In the course of this revision the writer has not only made changes in the text so as to bring the subject matter up-to-date but has reorganized some of the chapters, provided some better illustrations and added 121 new figures.

The old chapter on Cytology has been deleted and in its place new chapters have been substituted on "The Living Cell" and on "Non-protoplasmic Cell Contents." Important additions have been made to the subject of the cell and its contents including an amplification of the subject matter on mitosis and new material on plasmodesma, waxes, plant hormones and vitamins.

A new chapter has been added on "Genetics and Evolution" in keeping with the needs of some of the courses in botany.

The chapters on "The Microscope" and on "Histological Technique" have been transferred from their former positions in the main body of the text to the back of the book where they now appear as Appendix I and Appendix II respectively. New material has been incorporated under both of these captions including modern methods

## PREFACE TO THE SIXTH EDITION

of fixation, staining, imbedding and mounting plant materials for microscopic examination.

The chapter on "Plant Tissues" has been lengthened and improved by the introduction of much new material on the structure and physiology of meristems, endodermis, tracheary tissue, laticiferous tissue, xylem, phloem, the stele, bundles, leaf and branch traces, gaps and nectaries.

The histological and physiological portions of the various chapters dealing with Plant Organs have also been augmented with considerable new text and illustrative material.

The Glossary has been retained and somewhat enlarged as has also the Classified List of Reference Works. A complete Index is also provided, making the data desired by the reader easily found.

Many new drawings, photographs and photomicrographs have been added in this revision which should prove helpful to the student. A considerable number of these are original; many have been borrowed.

The writer desires to express his gratitude to the various publishers and authors from whom permission to use a number of the cuts used in this edition was cheerfully granted. Acknowledgment for these is given under the respective cuts in the text. He is particularly indebted to Dr. A. F. Sievers and the Bureau of Plant Industry for the loan of a number of prints on medicinal plants from which cuts were prepared, to Instructor Richard W. St. Clair of the Massachusetts College of Pharmacy for valued assistance in photographing many of the original figures, to Dr. F. J. Bacon of the Biology Department of Western Reserve University who furnished photographs on *Zamia* plants, and to Asst. Professor H. L. Reed of the Massachusetts College of Pharmacy who contributed the prints from which Figs. 138, 139 and 140 were prepared.

Finally, the author wishes to express his appreciation to P. Blakiston's Son & Co. Inc. for doing its utmost in producing an attractive and well bound book.

HEBER W. YOUNGKEN

BOSTON, MASSACHUSETTS,  
June 1938

## *Preface to the First Edition*

The aim has been to eliminate from this book all those topics that are of minor importance to the student and practitioner of Pharmacy. As a pharmacist and teacher, the writer feels that the botanical preparation for Pharmacognosy and *Materia Medica*, in those colleges where Botany is given for one year, should include mainly the structural and systematic aspects of the science. In the Medico-Chirurgical College, of Philadelphia, Botany is taught the first year, extending over a period of 155 hours. The author has introduced in this concise volume the important subject matter of his lectures given to first year students, and has omitted laboratory directions for the obvious reason that fixed subjects for laboratory study are unnecessary. It is not a book on Pharmacognosy, however, since it does not describe how one drug differs from another of the same group in all of its details.

The work is included in two parts. Part I is largely devoted to the morphology (gross and minute) and, to a less extent, the physiology of the Angiosperms. Part II deals with the taxonomy of plants, mainly but not wholly of medicinal value, together with the parts used and the names of the official and non-official drugs obtained from these.

The author does not claim sole originality for the facts presented, but has consulted many sources of information, mention of which will be found in the bibliography of the text.

Acknowledgment is here made to his esteemed friends, Dr. Francis E. Stewart of the Medico-Chirurgical College and Dr. John M. Macfarlane of the Univ. of Penna., for valuable assistance in the reading of the proofs and preparation of the index.

H. W. Y.

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## Acknowledgments

The following figures in this volume have been reproduced from the Blakiston books indicated:

Atwood: "Biology"—Figures 171, 172, 276, 359.

Atwood: "Civic and Economic Botany"—Figures 50, 397.

Braun: "Deciduous Forests of Eastern North America"—Figure 194.

Brownell: "General Science"—Figure 84.

Emerson: "Basic Botany"—Figures 3, 6, 8, 10, 47, 65, 81, 87, 88, 90, 283, 284, 287, 289, 290, 301, 373, 405.

Gager: "General Botany"—Figures 7, 31, 62, 67, 68, 69, 70, 92, 94, 104, 123, 167, 187, 197, 206, 240, 273, 275, 277, 280, 291, 292, 293, 311, 324, 337, 344, 345, 347, 351, 354, 360, 362, 370, 371, 372, 374, 385, 388, 392, 393, 396, 412, 415, 416, 426, 428, 458, 479, 513, 522.

Gibbs: "Botany—An Evolutionary Approach"—Figures 11, 198, 199.

Hamaker: "The Principles of Biology"—Figures 125, 127, 406.

Harshberger: "A Textbook of Mycology and Plant Pathology"—Figures 330, 331, 333, 334, 336, 341, 342, 350.

Jenkins: "Interesting Neighbors"—Figures 200, 202, 203.

Livingston: "Palladin's Plant Physiology"—Figures 4, 64, 86, 91, 270, 271.

Marshall: "Microbiology"—82, 314, 315, 316, 317, 318, 319, 320, 321, 322.

Mottier: "A Textbook of Botany for College Students"—Figures 5, 9, 21, 23, 29, 30, 40, 51, 53, 74, 89, 120, 145, 186, 190, 216, 285, 286, 295, 304A-C, 325, 326, 349, 356, 395, 398, 414.

Robbins: "The Botany of Crop Plants"—Figures 2, 39, 60, 61, 93, 139, 140, 141, 170, 174, 175, 182, 226, 417, 418, 420, 435, 439, 457, 463, 482, 484, 495, 524.

Sayre: "Manual of Organic Materia Medica and Pharmacognosy"—Figures 105, 108, 211, 230, 232, 352, 380, 422, 423, 425, 427, 433, 437, 438, 442, 445, 448, 449, 452, 453, 454, 455, 456, 459, 461, 462, 464, 465, 466, 468, 469, 470, 471, 472, 473, 474, 478, 483, 485, 488, 489, 490, 491, 498, 500, 503, 505, 512, 517, 520, 523.

#### *ACKNOWLEDGMENTS*

Schneider: "The Microanalysis of Powdered Vegetable Drugs"—  
Figures 242, 244.

Schneider: "Pharmaceutical Bacteriology"—Figures 327, 328,  
329, 332, 335.

Stevens: "Plant Anatomy"—Figures 18, 22, 24, 32, 48, 98, 99,  
100, 101, 113, 114, 115, 212, 217, 218, 223, 224, 225, 228, 233,  
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Walton and Foss: "Social Biology"—Figure 279.



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## *Scope and Importance of Botany*

**BOTANY** is the science which treats of plants. Plants are living things or organisms belonging to one of the two great kingdoms of living things, called the **Vegetable** or **Plant Kingdom**. The other kingdom of living creatures is that made up of animals and called the **Animal Kingdom**. The science which treats of animals is called **Zoology**. Botany and Zoology collectively constitute the branch of natural science called **Biology**, the science which seeks to inquire into all living things.

The term botany is derived from the Greek word *βοτάνη* meaning pasture, grass, or fodder. Man's first inquiry into plants was undoubtedly prompted by his instinct to seek food, and doubtless began with his first appearance on the earth. History records the first pursuit of botany as a science by the ancient Assyrians, Chaldeans, Egyptians, and Greeks, who cultivated it particularly in relation to sources of food supply. The Greek philosopher Aristotle (384–322 B.C.) early commented on certain of the problems of plant life.

Early man found that some plants possessed medicinal properties and his interest was then focused in the direction of plants as sources of medicines. The earliest pioneers in pharmaceutical botany were the medicine men of primitive peoples including the Indians of America, who were acquainted with the virtues of many medicinal plants before the coming of the white settlers. They were followed in Europe by the *rhizotomoi* or root collectors who gathered medicinal herbs and prepared them for the *pharmacopolai* or drug vendors. Probably the greatest of the early European pioneers in this field was Theophrastus of Eresus, a Greek philosopher and pupil of Aristotle, who lived between 372 and 287 B.C. He wrote 10 books on the "History of Plants" in which about 500 species of plants used in the treatment of various diseases are described. Dioscorides, a Greek physician, about A.D. 77 wrote a "Materia Medica" which included a large number of descriptions of medicinal plants and all the medicinal substances then known together

with their properties. For over 16 centuries his text was recognized as the supreme authority on these subjects. The early Romans also contributed to the development of Pharmaceutical Botany. Outstanding among these were Pliny the Elder (A.D. 23-79), who in his "*Historia Naturalis*" crudely described about 1000 plants, many of which possessed medicinal properties, and Galen (A.D. 131-200), a Graeco-Roman, who wrote a "*Materia Medica*."

During the Middle Ages German botanists known as herbalists contributed books containing crude classifications and descriptions of plants mostly of purported curative value. These books were known as "herbals." Outstanding among these herbalists were Otto Brunfels (1464-1534), who wrote "*Herbarum Vivae Icones*" ("Living Pictures of Herbs"); Hieronymus Bock (1498-1554) who issued his "*Kreuterbuch*"; Gaspard Bauhin (1560-1624), author of "*Pinax theatri botanici*"; Leonhard Fuchs (1501-66), who wrote "*De historia stirpium*"; and Valerius Cordus (1515-44), the most original writer of them all. Cordus instilled renewed vigor into botany by describing, direct from nature, about 450 plants which he found in his field trips in the forests and mountain glens of his native land. His greatest work, "*Historia Plantarum*," was edited and published posthumously by Conrad Gesner in 1561. During the latter part of the sixteenth century and in the seventeenth century, a number of English botanists contributed herbals, containing further data on medicinal and aromatic plants. Notable among the English herbalists were John Gerarde, who issued his "*Herbal*" in 1597; Nicolas Culpeper, who wrote "*A Complete Herbal*," published in 1653; and John Parkinson, who contributed "*Theatrum botanicum*" in 1640.

The ancient writers in botany and the herbalists gave little attention to the systematic classification of plants. In most of their works, plants were grouped according to size as herbs, shrubs, and trees, or according to the sequence of the alphabet. Many of the plant names found in their writings were long Latin sentences. It remained for Cesalpino, an Italian botanist, to introduce the first thorough and well-organized system of classification based upon those described. His "*De Plantis*" appeared in 1583. By the middle of the eighteenth century many thousands of plants native to the Old and New World became known, and the most orderly arrangement for the plants then recognized was given by the great Swedish botanist, Carlus Linnæus, in his "*Species Plantarum*" of 1753. Linnæus also founded the binomial system of classification which reduced the name of every species of plant to two words. This simpler system has prevailed to the present day.

Attention was thus concentrated upon the classification of plants, and gradually investigations followed on their structure, functions, development, geographical distribution, habits, relationships, diseases.

etc., until today the scope of botanical study embraces every kind of inquiry about plants.

The field of botany has thus developed many specialties or departments of inquiry.

### Departments of Botanical Inquiry

**1. Plant Morphology** treats of the parts, or structure, of plants. It is divided into:

(a) **MACROMORPHOLOGY** or **GROSS ANATOMY OF PLANTS**, which deals with the external characters of plants and of their parts or organs; (b) **MICROMORPHOLOGY**, **PLANT ANATOMY**, or **PLANT HISTOLOGY**, which considers the minute or microscopic structure of plants and plant tissues; and (c) **PLANT CYTOLOGY**, which treats of plant cells and their contents.

Plant Anatomy and Morphology were founded in the seventeenth century by Marcello Malpighi in Italy, and Nehemiah Grew in England.

**2. Plant Embryology** treats of the stages of growth, differentiation, and development of the individual plant body.

**3. Plant Physiology** deals with the study of the life processes or functions of plants. It explains how the various parts of plants perform their work of nutrition, growth, reproduction, and the preparation of food for the support of animal life from substances not adapted to that use.

**4. Taxonomy of Plants** or **Systematic Botany** considers the classification or arrangement of plants in groups in accordance with their relationships to one another. It also is concerned with the identification, the accurate description, and the naming of plants. All of the plants found growing in a certain region constitute the *flora* of that region.

**5. Plant Ecology** treats of plants and their parts in relation to their environment—i.e., to soil, moisture supply, temperature, light, and other plants and animals.

**6. Plant Genetics** deals with the coming into being of new individuals or races of plants. It seeks to account for the resemblances and differences shown by plants related by descent.

**7. Plant Pathology** or **Phytopathology** treats of diseases of plants.

**8. Plant Geography** or **Phytogeography** treats of the distribution of plants upon the earth. The center of distribution for each species of plant is the *habitat* or the original source from which it spreads, often over widely distant regions. When plants grow in their native countries they are said to be *indigenous* to those regions. When they grow in a locality other than their original home they are said to be *naturalized*.

**9. Geologic Botany or Phytopaleontology** treats of plants of former ages of the earth's history traceable in their fossil remains.

**10. Cryptogamic Botany** is the botany of the flowerless plants or cryptogams, such as the pond scums, fungi, mosses, ferns, and their allies.

**11. Phanerogamic Botany** is the botany of seed plants.

**12. Algology** is the botany of algae.

**13. Mycology** is the botany of fungi.

**14. Bryology** is the botany of mosses and liverworts.

**15. Dendrology** treats of the natural history of trees.

**16. Plant Microtechnic** deals with methods and procedures of preparing microscopic slides of plant materials.

**17. Economic or Applied Botany** deals with the science from a practical standpoint, showing the special adaptation of the vegetable kingdom to the needs of everyday life. It comprises a number of subdivisions, viz.: **PHARMACEUTICAL BOTANY**, or the botany of drug, spice, dye, and poisonous plants; **BACTERIOLOGY**, which treats of micro-organisms called bacteria and with viruses; **PHARMACOGNOSY**, which treats of the history, commerce, selection, identification, valuation, and preservation of crude drugs and other raw materials of plant and animal origin; **AGRICULTURAL BOTANY** or **AGRONOMY**, which treats of crop plants; **HORTICULTURE**, which treats of the cultivation of garden and orchard plants; **FORESTRY**, which treats of the management of forests and of timber plants; **PLANT BREEDING**, or the application of principles of selection to the growing of improved races of plants. All of these subdivisions interlock closely with departments of pure botanical inquiry, and no training in either of them can be considered sound without the assimilation of the broad underlying principles of morphology, taxonomy, and physiology.

Pharmaceutical Botany should include a sound foundation in the morphology, taxonomy, and elementary physiology of plants before taking up its applied aspects, in order to prepare the student adequately for the more advanced studies of Pharmacognosy, Industrial Microscopy, and Drug Plant Cultivation.

### Importance of Botany to Man

General Botany should give to the student an over-all understanding of various members of the plant kingdom. With this understanding the student acquires a better appreciation of things which are contacted in everyday life. Not a day passes without plants and plant products playing a very important part in the life of everyone.

It is an established fact that without plants there could be no human or lower animal life, for green plants supply the food for all living animals and maintain the oxygen content of the atmosphere. They supply man with timber to build homes, ships, and furniture;



with hairs and fibers with which to manufacture clothing, papers, and books; with fuel to heat our buildings; with dyes to color our garments and ornaments and preparations; with oils and resins to manufacture our soaps, paints, and varnishes; with drugs to treat our ills; with raw materials for our explosives; with spices and flavorings to season our food; with vitamins without which we could not maintain our health; with perfumes, waxes, etc. In fact, for our very existence, comfort, and protection we are dependent upon plant life.

Again, many of the fundamental principles of biology and genetics have been first established through observations and experiments with plants.

We look to the plants for a large number of our drugs and to the patterns obtained by the examination of many of their constituents for the chemical synthesis of a large number of important organic chemicals, medicines, and dyes. Coal, representing the fossil remains of plants which lived millions of years ago, furnishes the chemist with the raw material from which he has built up hundreds of organic chemicals which are daily used in pharmacy, medicine, and the industries.

Numerous woody and herbaceous plants are used as ornamentals, and these add much to the pleasantness of our environment. Certain other species yield important insecticides which are valuable in controlling insect pests. The development of numerous synthetic poisons has not lessened the importance of such materials as rotenone, nicotine, pyrethrum, and sabadilla.

Man has come to realize the importance of vegetation in preventing erosion of the soil by wind and water and in water conservation.

Not all plants are beneficial, by any means. Food spoilage is caused by minute plant forms, as are certain diseases of both animals and plants. Certain kinds of plants are poisonous to humans and to other animals either upon contact or when ingested in sufficient amounts. Many plants occur as weeds in our gardens and in the soil amidst farm crops, and add millions of dollars annually to the cost of food production.

Without some of the microscopic forms of plants, especially the bacteria, yeasts, and molds which represent agencies of decay and fermentation, the earth would be literally covered with the remains of the dead bodies of animals and plants accumulated through the ages. While a number of these produce disease, most are believed to be harmless, and many are of great economic importance to pharmacy, to agriculture, and to the dairy, alcohol, and tanning industries.

The study of botany unfolds many of Nature's secrets, enhances one's appreciation of Nature's beauty, develops one's powers of observation, and forms a sound foundation for the understanding of many problems in pharmacy, chemistry, agriculture, industry, and the biologic sciences.