

PHARMACEUTICAL BOTANY

A TEXT-BOOK FOR STUDENTS OF
PHARMACY AND SCIENCE

BY

HEBER. W. YOUNGKEN, A.M., M.S., PH.M., PH.D.
PROFESSOR OF BOTANY AND PHARMACOGNOSY AND DIRECTOR OF THE MICROSCOPICAL
LABORATORIES IN THE PHILADELPHIA COLLEGE OF PHARMACY AND SCIENCE

THIRD EDITION, REVISED AND ENLARGED
WITH 238 ILLUSTRATIONS
AND GLOSSARY OF BOTANICAL TERMS

PHILADELPHIA
P. BLAKISTON'S SON & CO.
1012 WALNUT STREET

PREFACE TO THE THIRD EDITION

The author has first endeavored to present in a clear, systematic way those fundamental principles of structural and taxonomic botany which serve as a key to the approach of pharmacognic problems. But he has not been unmindful that the use of the work has extended to academic institutions and, so, in this edition, has broadened the scope of the former text. To this end about ninety additional pages of subject matter have been introduced. Several old cuts have been removed. Forty-three new ones have been inserted. Hypothetical discussions have been avoided which saves time for the reader.

The arrangement and plan of the chapters are similar to that of the former edition, in order to adapt the work to several methods of approach. Chapter I on "Fundamental Considerations" has been augmented by treatises on Botanical Nomenclature, Paraffine and Celloidin Imbedding, Sectioning, Staining and Mounting, Microtomes and other information dealing with the preparation of materials for microscopic examination.

Ten pages have been added to Chapter V on cytology. Under "Protoplasm and its Properties," six pages have been written on the subject of Irritability and Irritable Reactions. Under "Non-Protoplasmic Cell Contents" several additional commercial starches are discussed and two original plates of starch grains added. Additional cuts on Collenchyma, Stone Cells, Sclerenchyma Fibers, Trichomes and Fibrovascular Bundles have been inserted in Chapter VI.

Nine additional pages of subject matter and illustrations have been added to Chapter VII. Original figures of all of the important types of fruits appear here for the first time.

Chapter VIII on "Taxonomy" has been increased by seven pages of new data, and the whole former text carefully revised.

Chapter IX on "Ecology" has been newly introduced as has also a Glossary of Botanical Terms. The index has been so planned as to make the information contained in this book readily accessible.

To the authors of works from which cuts were borrowed the writer's thanks are due.

H. W. Y.

PREFACE TO THE SECOND EDITION

The appearance of the United States Pharmacopœia IX and the National Formulary IV, with the many changes in the lists and definitions of officially recognized vegetable drugs made it necessary to revise the former edition of this work.

In the course of revision, the writer has taken cognizance of the growing importance of Botany in the curricula of pharmaceutical institutions and has accordingly expanded upon the subject matter of the former text.

With the adoption for the first time by the new United States Pharmacopœia of pharmacognic standards for numerous drugs, Pharmacognosy has risen to the forefront in this country as a science. While its proper comprehension requires laboratory instruction in chemistry, physics, and crystallography as well as botany, nevertheless a rather extended foundation in structural botany stands out preëminently as the most needed requirement.

The work has been for the most part remodeled. Chapter I deals with Fundamental Considerations. Chapter II is devoted to the life history of the Male Fern, a median type of plant, the consideration of which, after the students have received fundamental practice in the use of the microscope, the writer has found commendable, for it not only gives beginners a working knowledge of structures and functions, the homologies and analogies which will be met in the later study of forms of higher and lower domain, but holds their interest on account of its economic importance.

The life history of a type of Gymnosperm, White Pine, is next taken up in Chapter III. Chapter IV considers the life history of an Angiosperm as well as coordinates the resemblances and differences between Gymnosperms and Angiosperms. Chapters V, VI and VII are devoted respectively to Vegetable Cytology, Plant Tissues and Plant Organs and Organisms. Among the many additions to

the topics included in these might be mentioned a treatise on Cell Formation and Reproduction including Indirect Nuclear Division, twenty pages on Non-Protoplasmic Cell Contents, the consideration of Woods, Root Tubercles, the gross structure and histology of different types of leaves, broad histologic differences between Monocotyl and Dicotyl leaves, the histology of floral parts and the histology of types of fruits and seeds. Chapter VIII on Taxonomy has been increased by the addition of 144 pages. Several new families of drug-yielding plants have been added and the treatment of family characteristics has in the majority of instances been broadened. The habitats of drug-yielding plants have been added. In that portion of the tables dealing with the names of official drugs, those official in the National Formulary have been so designated by the abbreviation N. F., to distinguish them from others that may occur in the same portion of the table and which are official in the Pharmacopœia.

In keeping with the increased size of the book, many new illustrations have been introduced. A number of these are original drawings, photographs and photomicrographs. To the authors of other works from which cuts were borrowed, the writer's thanks are due.

The writer in conclusion desires to thank Dr. John M. Macfarlane, head of the Botanical Department of the University of Pennsylvania, for valuable suggestions during the preparation of portions of the text.

H. W. Y.

CONTENTS

CHAPTER I

FUNDAMENTAL CONSIDERATIONS

	PAGES
DEPARTMENTS OF BOTANICAL INQUIRY.—1. Morphology (Gross Anatomy, Histology, Cytology). 2. Physiology. 3. Taxonomy or Systematic Botany. 4. Ecology. 5. Genetics. 6. Phytopathology. 7. Phytogeography. 8. Phytopalæontology. 9. Etiology. 10. Economic Botany and its subdivisions.....	1-2
PRINCIPLES OF CLASSIFICATION.—Natural System: species; genus; family; order; class; subdivision; division; variety; race; hybrid.....	2-3
OUTLINE OF PLANT GROUPS.....	3-4
BOTANICAL NOMENCLATURE.....	4-7
THE MICROSCOPE.—Definition. The simple microscope. The dissection microscope. The compound microscope: its construction and use. The binocular microscope. Rules for the care of the microscope.....	7-14
MAKING OF SECTIONS.—Free hand sectioning. Kinds of sections. Microtomes (hand, sliding and rotary), their construction and use.....	15-20
THE TECHNIQUE OF MAKING A TEMPORARY MOUNT.....	20
THE TECHNIQUE OF MAKING PERMANENT MOUNTS.—The mounting medium; Staining. Method for Preparation of a Canada Balsam Mount. Method for the Preparation of a Glycerin-Gelatin Mount. Technique of Fixing, Dehydrating, Hardening and Imbedding in Paraffine. Technique of Sectioning and Mounting Material Imbedded in Paraffine. Method for the Staining and Mounting of Material in Paraffine Ribbons affixed to slide. Imbedding in Celloidin. Sectioning Celloidin Material. Staining and Mounting Celloidin Sections.....	20-30
DESILICIFICATION. SCHULZE'S MACERATION PROCESS.....	30-31
MICROMETRY.—Unit of microscopical measurements. Standardization of the Ocular Micrometer.....	31-32

CHAPTER II

LIFE HISTORY OF THE MALE FERN

HISTORY OF THE SPOROPHYTE OR ASEXUAL GENERATION.

PAGES

—Gross structure of stem. Histology of mature stem. Histology of growing apex. Histology of mature root. Histology of root apex. Continuity of crude sap flow. Histology of stipe. Histology of lamina. Comparative physiology of root, stem and leaf. Gross structure and histology of the sori and sporangia. Rupture of sporangium and spore dissemination. HISTORY OF THE GAMETOPHYTE OR SEXUAL GENERATION.—Origin of new sporophyte or diploid plant from fertilized egg. Growth of seedling into mature sporophyte. Alternation of generations.....

33-44

CHAPTER III

LIFE HISTORY OF A GYMnosperm (PINUS STROBUS)

DESCRIPTION OF THE WHITE PINE TREE (SPOROPHYTE).

—Staminate cones. Carpellate cones. DESCRIPTION OF THE GAMETOPHYTE GENERATION.—The Male Gametophyte. The Female Gametophyte. Fertilization. Seed Formation and Distribution. GERMINATION OF THE SEED.....

45-52

CHAPTER IV

LIFE HISTORY OF AN ANGIOSPERM

DESCRIPTION OF THE DOG'S TOOTH VIOLET.—Development of Female Gametophyte. Maturation of the Pollen Grain and formation of the Male Gametophyte. Pollination and Fertilization. Ripening of the Ovule to form the Seed and of the Ovary to form the Fruit. Germination of the Seed and development of the Mature Sporophyte.....

53-58

RESEMBLANCES BETWEEN GYMnosperms AND ANGIOSPERMS.....

58

FUNDAMENTAL DIFFERENCES BETWEEN GYMnosperms AND ANGIOSPERMS.....

58-59

CHAPTER V

VEGETABLE CYTOLOGY

	PAGES
VEGETABLE CYTOLOGY.—Definition. The Plant Cell as the Fundamental Unit. A typical Plant Cell.....	60-61
PROTOPLASM AND ITS PROPERTIES.—Structure. Metabolism. Irritability (Thermotropism, Chemotropism, Sitotropism, Hydrotropism, Heliotropism, Geotropism, Galvanotropism, Thigmotropism.) Reproduction.....	62-68
PROTOPLASMIC CELL CONTENTS.—Cytoplasm; nucleus; nucleolus; plastids (leucoplastids, chloroplastids, chromoplastids)	68-70
CELL FORMATION AND REPRODUCTION.—Asexual and sexual cells. Reproduction defined. Asexual Reproduction: Fission; Gemmation; Free Cell Formation; Rejuvenescence. Sexual Reproduction: Conjugation and Fertilization.....	70-71
INDIRECT NUCLEAR DIVISION.....	71-74
NON-PROTOPLASMIC CELL CONTENTS.—Sugars. Starch. Inulin. Hesperidin. Strophanthin. Salicin. Saponin. Coniferin. Digitoxin. Characteristics of Glucosides. Alkaloids and their properties. The alkaloids, Strychnine, Veratrine, Nicotine, Caffeine, Cocaine, Aconitine, Colchicine. Gluco-alkaloids. Asparagine. Calcium Oxalate. Cystoliths. Silica. Tannins. Proteins. Aleurone Grains. Mucilages and Gums. Fixed Oils and Fats. Volatile Oils. Resins. Oleoresins. Gum Resins. Balsams. Pigments. Latex. Enzymes. Classification of Enzymes.....	74-96
CELL WALLS.—Their formation and composition. Growth in area and thickness. Various kinds of cell walls and behavior of each to micro-chemical reagents.....	96-98

CHAPTER

PLANT TISSU

PLANT TISSUES.—Tissue defined. The Tissues of Spermatophytes and Pteridophytes: Generative Tissue. List of Tissues.....	99-100
MERISTEM.—Definition. Primary and secondary meristems; their distribution.....	100

	PAGES
PARENCHYMA.—Definition; ordinary parenchyma; assimilation parenchyma; conducting parenchyma; reserve parenchyma; their structure, distribution and function.....	101-103
COLLENCHYMA.—Definition, function and distribution.....	103
SCLERENCHYMA.—Definition; stone cells; sclerenchyma fibers; wood fibers; bast fibers; their distribution.....	103-106
EPIDERMIS.—Definition; transpiration and water stomata; epidermal papillæ; trichomes; scales; their distribution and functions.	106-109
ENDODERMIS.—Definition, distribution and functions	109-110
CORK.—Definition; its derivation, function and distribution	110
LATICIFEROUS TISSUE.—The structure, origin, distribution of latex cells, laticiferous vessels and secretory cells. Latex . .	110-112
SIEVE (LEPTOME OR CRIBIFORM) TISSUE.—Definition; distribution; function	112
TRACHEARY TISSUE.—Tracheæ: Definition, function and classification; Tracheids: Definition and function.	112-116
MEDULLARY RAYS.—Primary and Secondary; their distribution and functions	116-117
FIBRO-VASCULAR BUNDLES.—Definition of the various types; the distribution of each type; Xylem and Phlœm.	117-119
SECRETION SACS.—Definition and distribution	119
INTERCELLULAR AIR SPACES.—Definition; schizogenous and lysigenous air spaces; their relative size.	119
SECRETION RESERVOIRS.—Definition; structure; internal glands; secretion canals	119-120
CLASSIFICATION OF TISSUES ACCORDING TO FUNCTION	120

CHAPTER VII

PLANT ORGANS AND ORGANISMS

PLANT ORGANS AND ORGANISMS.—Organ and organism defined. Vegetative Organs: Root, stems and leaves. Reproductive Organs: Flower, fruit and seed. Embryo and its parts; function of the cotyledon	121
---	-----

	PAGES
THE ROOT.—Definition; functions; root hairs; root cap; generative tissues; differences between root and stem.	121-123
CLASSIFICATION OF ROOTS AS TO FORM.—Primary root; tap root; secondary roots; fibrous and fleshy roots; anomalous roots; adventitious roots; epiphytic roots; haustoria.	123-124
CLASSIFICATION OF PLANTS ACCORDING TO DURATION OF ROOT.—Annual; Biennial; Perennial	124
ROOT HISTOLOGY.— <i>A. Monocotyledons. B. Dicotyledons</i> ; Histology and Development of the California Privet root; Abnormal structure of Dicotyl roots; Histology of a Dicotyl Tuberous Root, <i>Aconitum</i>	124-132
ROOT TUBERCLES.—Definition; occurrence on roots of Leguminosæ, Myricacæ, etc.; their etiology.	132-135
THE BUD.—Definition; plumule, scaly buds, naked buds; Classification of Buds According to Position on Stem: terminal bud; axillary or lateral bud; adventitious bud; accessory bud. Classification of Buds According to Development: leaf bud; flower bud and mixed bud. Classification of Buds According to their Arrangement on the Stem: alternate; opposite; whorled.	135-136
THE STEM.—Definition; direction of growth; functions; size; nodes and internodes; stem elongation; duration of stems; stem modifications; above ground stems; herb and tree defined; underground stems; exogenous and endogenous stems.	136-140
STEM HISTOLOGY.—Annual Dicotyl; Perennial Dicotyl; Exceptional Types of Dicotyl Stems; Lenticels and Their Formation; Annual Thickening of Stems; Method of Formation; "Annual Ring." Bark: Definition; zones; Periderm; Phelloderm; Histology of <i>Cascara Sagrada</i> bark. Wood: alburnum; duramen; microscopic characteristics of Angiospermous and Gymnospermous woods; Histology of Typical Herbaceous Monocotyl Stems; Histology of Typical Woody Monocotyl Stem	140-154
THE LEAF.—Definition; leaf functions: photosynthesis; assimilation; respiration; transpiration	155
TYPES OF LEAVES DEVELOPED IN ANGIOSPERMS.—Cotyledons; Scale leaves; Foliage leaves; Bract leaves: bracts and bracteoles; Sepals; Petals; Microsporophylls; Megasporophylls	155-156

	PAGES
ORIGIN AND DEVELOPMENT OF LEAVES.—Primordial leaf.	
Its formation	156
PHYLLOTAXY.—Definition; spiral law of leaf arrangement; alternate; opposite, decussate; whorled; fascicled; leaf rank.	156-157
VERNATION.—Definition; inflexed or reclinate; conduplicate; con- volute; circinate; plicate; involute; revolute	157-158
THE COMPLETE LEAF.—Its parts; sessile; petiolate; exstipulate; stipulate	158-159
LEAF VENATION.—Furcate; parallel; reticulate; pinnate-veined; palmately veined; anastomosing veins	159
LEAF INSERTION.—Definition; radical; cauline; ramal; perfoliate; amplexicaul; connate-perfoliate; equitant	159-161
FORMS OF LEAVES.—Simple and Compound. (a) General Outline: ovate; linear; lanceolate; elliptical; oblong; inequilateral; or- bicular; peltate; filiform; oblanceolate; cuneate; spatulate; en- siform; acerose; deltoid. (b) Apex: acute; acuminate; obtuse; truncate; mucronate; cuspidate; aristate; emarginate; retuse; obcordate. (c) Base: cordate; reniform; hastate; auriculate; sagittate. (d) Margin: entire, serrate; dentate; crenate; repand; sinuate; incised; runcinate; lobed; cleft; parted; di- vided. Forms of Compound Leaves	161-166
LEAF TEXTURE.—Membranous; succulent; coriaceous	166
LEAF COLOR.—Variations in color	166
LEAF SURFACE.—Glabrous; glaucous; pellucid-punctate; scabrous; pubescent; villose; sericeous; hispid; tomentose; spinose; rugose; verrucose.	166
DURATION OF LEAVES.—Persistent or evergreen; deciduous; cadu- cous; fugacious.	167
GROSS STRUCTURE AND HISTOLOGY OF THE LEAF PETIOLE. —In Monocotyledons. In Dicotyledons. Pulvinus. Peri- cladium.	167-168
STIPULES.—Definition; lateral; free-lateral; lateral-adnate; lateral- connate; lateral interpetiolar. Axillary; ochrea. Modified Stipules.	168-169

THE LAMINA.—Definition. Mode of Development of the Lamina of Leaves: Dorsoventral; convergent; centric; bifacial; reversed; ob-dorsoventral. <i>A.</i> Dorsoventral: (<i>a</i>) Dorsoventral Umbrophytic; (<i>b</i>) Dorsoventral Mesophytic; (<i>c</i>) Dorsoventral Xerophytic; (<i>d</i>) Dorsoventral Hydrophytic. Gross Structure and Histology of Different Types of Dorsoventral Leaf Blades. Gross Structure and Histology of the following types: <i>B.</i> Convergent; <i>C.</i> Centric; <i>D.</i> Bifacial.	169-173
STRUCTURE AND DEVELOPMENT OF STOMATA	173-176
HISTOLOGIC DIFFERENCES BETWEEN LEAVES OF DICOTYLEDONS AND MONOCOTYLEDONS	176
INFLORESCENCE.—Definition; Parts of Inflorescences; Determinate; Indeterminate; Mixed Forms of Indeterminate and Determinate Inflorescences	177-180
PRÆFLORATION.—Convolute; involute; revolute; plicate; imbricate; valvate; vexillary; contorted.	180
THE FLOWER.—Definition; floral parts; essential organs; complete; perfect; hermaphrodite; regular; symmetrical; imperfect; double; staminate; pistillate; neutral; connation; adnation.	181-183
THE RECEPTACLE, TORUS OR THALAMUS.—Definition; variations in structure; anthophore; gonophore; gynophore; carpophore.	183
THE PERIGONE.—Definition; dichlamydeous; monochlamydeous	183
THE CALYX.—Definition; parts; physical characteristics; connation; kinds and forms; persistence; adnation; sepaline spur; sepaline stipules; sepaline position	183-185
THE COROLLA.—Definition; parts; physical characteristics; functions. Forms of the Corolla and Perianth.	185-188
THE ANDRŒCIUM OR STAMEN SYSTEM.—Definition; parts; terms denoting number of stamens in flower; insertion of stamens; proportions of stamens; connation of stamens; stamen color. Gross Structure and Histology of the Filament. Gross Structure and Histology of the Anther. Anther Dehiscence. Development of the Anther. Attachment of Anther. Pollen: description; forms	188-195

	PAGES
THE GYNÆCIUM OR PISTIL SYSTEM.—Definition; Gymnospermous and Angiospermous; parts; the pistil a modified leaf; carpel; dehiscence; apocarpous and syncarpous pistils; terms denoting the number of carpels entering into the formation of the pistil; compound pistils; ovules or megasori as transformed buds; position of ovules in ovary; Gymnospermous and Angiospermous ovules; structure of Angiospermous ovule; shape of ovule	195-197
THE PLACENTA.—Definition; types of placenta arrangement . . .	197
THE STYLE.—Definition; style-arms; relation to carpels forming the gynæcium; variations from typical stylar development . . .	198
THE STIGMA.—Definition; forms in wind- and animal-pollinated flowers; stigmatic papillæ	199
POLLINATION.—Definition; Close and Cross Pollination; terms applied to plants pollinated by various agencies	199-200
MATURATION OF THE POLLEN GRAIN AND FORMATION OF MALE GAMETOPHYTE	200
MATURATION OF THE EMBRYO SAC AND FORMATION OF THE FEMALE GAMETOPHYTE	200
FERTILIZATION IN ANGIOSPERMS.—Process; formation of embryo and endosperm	200-201
THE FRUIT.—Definition; modifications	202
FRUIT STRUCTURE.—Pericarp; pseudocarp; anthocarp; epicarp; mesocarp; endocarp; sarcocarp; putamen; sutures; valves; dehiscence.	202-204
CLASSIFICATION OF FRUITS.—Simple; Aggregate; Multiple; dry dehiscent; dry indehiscent; fleshy indehiscent. Forms of Simple Fruits: capsular; schizocarpic; achenial; baccate; drupaceous. Etereo. Forms of Multiple Fruits; strobile or cone; sorosis; syconium; galbalus.	204-211
HISTOLOGY OF A CAPSULE, ANILLA.	211-212
HISTOLOGY OF A MERICARP FENICULUM.	212-213
THE SEED.—Definition; structure; functions; appendages	213-214
MODE OF FORMATION OF DIFFERENT TYPES OF ALBUMEN. —Perispermic; endospermic; perispermic and endospermic; exalbuminous and albuminous seeds	214-215

CONTENTS

xix

PAGES

A MONOCOTYL SEED.—Its gross structure and histology.	215-216
A MONOCOTYL SEEDLING.—Germination and structure.	216-217
A DICOTYL SEED.—Its gross structure and histology.	217-218

CHAPTER VIII

TAXONOMY

THALLOPHYTA.—Definition. Characters of the Protophyta, Myxomycetes, Algæ, Fungi and Lichenes. The Mounting and Staining of Bacteria. Life histories of representative types of Thallophytes. Plants of the group yielding drugs and economic products	219-282
BRYOPHYTA.—Definition. Characters of the Hepaticæ and Musci. Life history of a typical true moss	282-287
PTERIDOPHYTA.—Definition. Characters of the Lycopodineæ, Equisetineæ and Filicineæ. Life history of a typical fern. Plants of the group yielding official drugs	287-292
SPERMATOPHYTA (PHANEROGAMIA).—Definition. Characteristics of the Gymnosperms and of the Order and Family yielding important drugs and economic products. Table of official and unofficial drugs yielded by Gymnosperms including part of plants used, botanical origins and habitats. Characteristics of the Angiosperms and of the classes and families yielding drugs. Tables of official and unofficial drugs with the names of the plants, parts constituting the drugs and habitats.	292-407

CHAPTER IX

ECOLOGY

PLANT ASSOCIATIONS.—Definition. Classification based on relation plant associations have assumed in regard to water. Characteristics of Hydrophytes, Helophytes, Halophytes, Xerophytes, Mesophytes and Tropophytes.	408-412
GLOSSARY.	412-440
INDEX.	441-479

PHARMACEUTICAL BOTANY

CHAPTER I

FUNDAMENTAL CONSIDERATIONS

Botany is the Science which Treats of Plants

DEPARTMENTS OF BOTANICAL INQUIRY

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

(a) **Macromorphology** or **Gross Anatomy** which deals with the external characters of plants or their parts; (b) **Micromorphology** or **Histology** which considers the minute or microscopical structure of plants and plant tissues; and (c) **Cytology** which treats of plant cells and their contents.

2. **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 growth, reproduction, and the preparation of food for the support of animal life from substances not adapted to that use.

3. **Taxonomy** or **Systematic Botany** considers the classification or arrangement of plants in groups or ranks in accordance with their relationships to one another.

4. **Ecology** treats of plants and their parts in relation to their environment.

5. **Plant Genetics** seeks to account for the resemblances and differences which are exhibited by plants related by descent.

6. **Phytopathology** treats of diseases of plants.

7. **Phytogeography** or **Plant Geography** 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*.

8. **Phytopalæontology** or **Geological Botany** treats of plants of former ages of the earth's history traceable in their fossil remains.

9. **Etiology** is the study of the causes of various phenomena exhibited by plants.

10. **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.: **Agricultural Botany**, **Horticulture**, **Forestry**, **Plant Breeding**, and **Pharmaceutical Botany**. **Pharmaceutical Botany** considers plants or their parts with reference to their use as drugs. It interlocks very closely with other departments of botanical science.

PRINCIPLES OF CLASSIFICATION

The classification of plants is an attempt to express the exact kinship which is believed to exist among them. By grouping together those plants which are in some respects similar and combining these groups with others, it is possible to form something like an orderly system of classification. Such a system based upon natural resemblances is called a **natural system**. In a natural system of classification every individual plant belongs to a *species*, every species to a *genus*, every genus to a *family*, every family to an *order*, every order to a *class*, every class to a *division*. In many instances species may be subdivided into *varieties* or races. The crossing of two varieties or species, rarely of two genera, gives rise to a *hybrid*. Thus, the species *Papaver somniferum* which yields the opium of the Pharmacopœia belongs to the genus *Papaver*, being placed in this genus with other species which have one or more essential characteristics in common. The genera *Papaver*, *Sanguinaria* and *Chelidonium*, while differing from each other in certain essential respects, nevertheless agree in other particulars such as having latex, perfect flowers, capsular fruits, etc., and so are placed in the *Papaveraceæ* family. The *Papaveraceæ* family and the *Fumariaceæ* family are closely allied, the latter only differing from the former in having irregular petals, usually diadelphous stamens and non-oily albumen and so both of these families are placed in the order *Papaverales*. The orders *Papaverales*, *Geraniales*, *Sapindales*, *Rhamnales*, etc., are

related by a common structure namely, two seed leaves or cotyledons and so are grouped together under the class *Dicotyledoneæ*. The *Dicotyledoneæ* differ from the *Monocotyledoneæ* in that the latter group possess but one cotyledon; but both classes agree in having covered ovules and seeds, and so are placed in the subdivision *Angiospermæ*. The *Angiospermæ* differ from the *Gymnospermæ* in that the latter possess naked ovules and seeds; but both of these subdivisions agree in producing real flowers and seeds. For these reasons they are placed in the division **Spermatophyta** of the Vegetable Kingdom.

OUTLINE OF PLANT GROUPS

I. Thallophyta	1. Protophyta	{ Bacteria Cyanophyceæ
	2. Myxomycetes	{ Acrasiales Phytomyxales Myxogastrales
	3. Algæ	{ Chlorophyceæ Phæophyceæ Rhodophyceæ
	4. Fungi	{ Phycomycetes Ascomycetes Basidiomycetes Fungi Imperfecti
	5. Lichenes	{ Crustaceous Foliaceous Fruticose
II. Bryophyta	1. Hepaticæ	{ Marchantiales Jungermanniales Anthocerotales
	2. Musci	{ Sphagnales Andreæales Bryales
III. Pteridophyta	1. Lycopodineæ	{ Lycopodiales Selaginiales Isoetales
	2. Equisetineæ	{ Equisetales
	3. Filicineæ	{ Ophioglossales Filicales