An Introduction to Plant Taxonomy

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AN INTRODUCTION TO

Plant Taxonomy

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PREFACE

THIS BOOK is written for the adult amateur botanist and the student of a local flora course at the college level. It is restricted in scope to the vascular plants—ferns, gymnosperms, and flowering plants. It is intended to provide sufficient information for an understanding of plant structures, a comprehension of why we have different contemporary systems of classification, an understanding of fundamental principles of plant nomenclature, and an appreciation of the mechanics of plant identification, including the preparation and preservation of herbarium specimens.

Taxonomy is a complex subject. It is based on a knowledge and understanding of plant morphology and anatomy, cytology, and genetics, as well as paleontology and plant geography. It is not presumed that the user of this book has knowledge or training in these subjects, but it is presumed that he has had the equivalent of an introductory course in biology or botany. This volume is intended to serve as an aid to the non-taxonomist in the use of a manual or flora that accounts for the plants of any region of North America.

In writing this book, I have drawn freely from pertinent parts of my earlier work, *Taxonomy of Vascular Plants* (1951). No bibliographies have been included, and persons desiring references to original and background papers are invited to consult that earlier work. In addition to the more general taxonomic situations, there has been included a selection of about fifty of the larger or more dominant families of vascular plants; for each there has been given their distinguishing characters, by which members of these families may be recognized at this classification level. A chapter on the history of taxonomic studies in the United States of America, as indicated by biographical sketches of the makers of this history, has been included to provide background and perspective.

The glossary provided in *Taxonomy of Vascular Plants,* corrected and amplified, is repeated in combination with an index. The figures used in the earlier glossary have been transferred to appropriate chapters of this new text. A study of glossaries in most floras and manuals demonstrated the need of bringing the definitions of many terms into harmony with modern concepts of morphological and anatomical situations. This is especially true of terms pertaining to the organs of the flower. Persons requiring a more complete glossary than provided here, or wishing to consult a listing of English equivalents of most specific epithets, are invited to consult Featherly, H. I., *Taxonomic Terminology of Higher Plants* (1954).

All illustrations in this book have been drawn by Mrs. Marion Ruff Sheehan, and many were prepared especially for this introductory work. Except as noted, these figures have been prepared from the plants themselves.

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CHAPTER I. *Introduction*

WHAT IS taxonomy?

Taxonomy is a science that treats of the identification, nomenclature, and classification of objects. When concerned with plants, it is often referred to as systematic botany, and in this book it is restricted to the systematics of ferns, of conifers and other gymnosperms, and of the flowering plants. These comprise the vascular plants. Taxonomy may be considered the mother of biological sciences. Before man could study plant structures, the way plants grow, or could accurately record the plants about him, he had to know the names and characteristics of those plants. In gaining this knowledge he has tried to group plants together in accordance with their presumed affinities. Today, anyone dealing with plants in any way depends on the labors of the taxonomist.

To understand the scope and functions of taxonomy, it is necessary to understand what is meant by identification, nomenclature, and classification. It is necessary also to understand how each of these differs from the others and how they are interdependent.

Identification is what one does when keying out an unknown, when determining the kind of a plant by comparing it with a plant of known identity, or with a description of such a plant. If someone tells you only the common name of a plant, he has identified it. The name given by this identification may not be correct, but the function or process remains the same. A more precise and formal definition of identification would be:

the determination of a plant as being identical with or similar to another and already known element; or, as being unlike any previously known element and therefore one that is new to science.

A plant may be identified by the aid of books or papers on the subject (such as manuals, floras, monographs, or revisions), or by comparing it with plants, the identity of which is already known (such as living plants in collections, or pressed and dried herbarium specimens). One must remember that identification, in the strict sense, has nothing to do with the correct name of the plant or with determining that name, for the latter—as we soon shall see—is a function of nomenclature. Suppose you are given an armful of all the known kinds of lilies, and that you spread them out on a table. Sorting them out, you place like kinds in separate piles. For purpose of easy reference, you then assign each pile a number. Having done this, assume that a neighbor hands you a lily from his garden. Immediately, you recognize it to be like those placed by you, for example, in pile number 8. By this recognition, you have identified the neighbor's lily. No name has been involved nor is the assigned number a part of that identification. Hence, it is seen that identification is a distinct function of taxonomy. Nomenclature is a very different function. In practice, one usually finds that a specialist or an author has handled the nomenclatural part so that, when one comes to the end of the identification, there also is the correct name for the plant.

Nomenclature has reference to the correct naming of the plant that has been identified. It is the part of taxonomy that tells us how to go about the determination of what name is correct, whether a particular name is only a synonym, or whether it has no standing at all. Botanical nomenclature deals only with the Latin names of plants. It is not concerned with common or English names (sometimes referred to as vernacular names). The naming of plants is controlled by rather rigid rules that are explained in the chapter on Nomenclature.

Classification is the placing of a plant (or group of plants) in categories according to a particular system, and in conformity with a nomenclatural system. A very simple system of classification is that which divides plants into such groups as trees, shrubs, and herbs. Another might divide them into ferns, conifers, dicots, and monocots. Classification is a grouping together of those plants whose similarities are greater than their differences. In practice, species of plants having many characters in common are united under the name of a genus, as the lilies are all treated as species of the genus *Lilium*. Related genera, such as the tulips, lilies, and fritillaries, for example, are classified as belonging to a single family, the *Liliaceae*. Modern systems of classification attempt to align the various groups of plants in accordance with their presumed relationships.

Taxonomy—its Significance

Any understanding of the natural resources of the earth requires an appreciation and knowledge of its plants. The role of taxonomy is all-pervading and fundamental; too often it is taken for granted. A primary objective of taxonomy, prerequisite to all studies and uses of plants, is to provide an accounting of the kinds growing on the earth. For the last two hundred years, and longer, botanists have worked toward the compilation of a list of the kinds of plants. This work has progressed at about the same rate as has man's scope and spread of communications. The development of steamship lines, of railroads, highways, and airways has enabled the botanist to penetrate regions never before explored. Despite these aids to travel, many significant parts of the earth remain to be thoroughly explored for their plants. The inventory, as it stands today, is far from complete. Probably we know of no more than three-fifths of the flowering plants of the world, and many of these are known imperfectly.

The plants of the earth compose its flora, just as the animals compose its fauna. One may refer to the flora of the world, to that of a continent, or to the flora of a political unit as a country, state, or county. Sometimes a book that merely lists the plants (with or without their descriptions) of a particular area is also referred to as a flora. The taxonomist's record of the flora is the *herbarium*. The specimens collected, pressed, and dried, compose the herbarium. In the 1700's and even later, the herbarium consisted of one or more scrapbook-like volumes on whose pages the dried specimens were pasted or sewed. Later, as collections increased in size, and allowance had to be made for continued expansion, the sheets were placed loose in folders and arranged in the pigeonholes of specially constructed cases. A collection of dried, pressed plants is an herbarium, no matter if occupying only a notebook or if contained in hundreds of cases. Each herbarium specimen is accompanied by a label giving the name of the plant, the place where collected, by whom and when. Other pertinent information should also be added. Each specimen serves as a permanent record that the plant grew at a given place, and that it was collected there at a particular season and year. It is only by assembling the plants of a major area in herbaria that the plants can be studied comparatively and that those of a wide area can be brought together to determine their similarities and differences.

These data about the kinds of plants are assembled in books or articles known as floras or manuals. While a flora lists or describes briefly the plants of a region, a manual assists the user in identifying a plant of that area. This is done usually by means of keys. Another form of presenting the results of taxonomic study is a monograph or revision. This is a comprehensive treatise on the taxonomy of a natural group, such as the genus *Rosa* (the rose) or the family Rosaceae (of which, for example, *Rosa, Spiraea, Prunus,* and *Amelanchier* are members). In general, the monograph differs from a revision in being more exhaustive and comprehensive. Studies by the taxonomist enable others not only to identify and name plants but also to handle intelligently the plant material and products with which they work. Clearly, taxonomic studies are fundamental to any subsequent study of the natural resources of an area or of land potentials, and to evaluations of the raw materials requisite to allied activities such as forestry, medicinal work, horticultural and agricultural pursuits, and pharmaceutical and biological industries.

Taxonomy demonstrates the great diversity of plants in nature and their relationships. In this way it aids in academic studies relating to the genesis, evolution, and heredity of plants. As documented knowledge of the earth's flora accumulates, the taxonomist can begin to understand better the inter-relationships of plants. From this knowledge he may form a better system of plant classification. Other botanists—the physiologist, ecologist, anatomist, cytogeneticist and morphologist—depend on taxonomic findings to identify and name the plants with which they work, as do others who work with plants and plant products. Here is one of the major functions of taxonomy.

Opportunities in Taxonomy

Floras have been written to account for the plants of most areas of the world. Many of these are over a century old and were written on the basis of scant collections made at the fringes of a country before railroads or roads existed or before modern concepts of adequate floristic coverage were developed. Many of these same areas are being explored anew, by trained men, and with collecting techniques unknown even a half-century ago.

These areas whose plants are inadequately known are not all tropical rain-forests, inaccessible arid regions, or Oriental lands difficult of access. Some are here in the United States, in Mexico, and in Canada. The flowering plants of the southeastern United States are not adequately known, those of northern and western Canada are only beginning to be known, and, despite existence of floras published during the present century, the lands of Central America and of Mexico have not been well explored for their plants. The problems are many and open to any student trained in taxonomy. In this country there is an acute need for more complete county floras, even of states presumed to be well botanized. No flora for Virginia, settled in 1607, has been written. It may be noted that many of our best county floras are the result of intensive field studies and collections by amateur botanists.

At the same time, other problems await resolution by the trained taxonomist who is most interested in monographic work. The need for revisions and monographs of plant groups is of increasing importance. Recently accelerated research in cortisone and allied products has focused attention on how little is known of the large genus *Dioscorea*. This is an isolated example. There are a thousand and more other genera equally in need of modern and thorough taxonomic study. Many of these are large genera, of a hundred or more species; others of equal importance are small and may have no more than a dozen species.

From the above, it should be clear that plant taxonomy is fundamental to all biological sciences and that its objectives have only begun to be achieved. With this perception of its underlying significance and scope, there should be the realization that taxonomy is not an end in itself, but that it is a tool by the use of which the student of other biological sciences—or facets of them—can bring his problems closer to fruition.

CHAPTER II. *Plant Classification*

PLANT CLASSIFICATION is the arrangement of plants into an orderly sequence. It may be based on the form of plants—whether trees, shrubs, or herbs. It may be based on numerical distribution of parts of the flowers—the number of stamens, pistils, or ovary locules. Or, it may be based on real or presumed phylogenetic relationships. Most classifications of plants from the time of Aristotle to the present have been of one or another of these three fundamental types.

Plant classifications follow a system of arrangement set forth by a specialist in matters of phylogeny. No less than fifty different systems have been proposed, with two or three holding positions of dominance in recent years. The differences in them often have been those of degree. During the centuries nothing has exerted greater influence than the introduction and establishment of the doctrine of evolution, the recognition of mutations arising in nature, and an understanding of the mechanics and principles of inheritance.

Changes in concept of taxonomic units and in taxonomic procedures reflect the influence of the same factors that have brought about changes in systems of classification. For this reason, a better appreciation of the problems involved is achieved if selected classificatory systems are briefly recounted and their significance described. A knowledge of them is essential to a comprehension of the objectives of taxonomy as a whole.

Early man classified plants before he had a written language. Certainly he ate plants, or parts of them, used them for shelter, and from them fashioned weapons for slaughter and defense. For each use, some sorts were found to be superior and others inferior. Man talked about these plants. Names for them were a prerequisite to communication, and, since many kinds of plants were involved, he must have classified them as well as identified and named them.

The first deliberate attempt to classify all of the plants known was that of Theophrastus (370–285 B.C.), noted student of Aristotle. His was a classification based on habit or form—trees, shrubs, undershrubs, and herbs—and he distinguished those of annual, biennial, or perennial duration. In addition, he distinguished between determinate and indeterminate inflorescences, between superior and inferior ovary position, and between polypetalous and gamopetalous corollas.

Although several classifications were published during the period from the time of Theophrastus to the seventeenth century, none was predominant until that set forth by Joseph Pitton Tournefort in 1700. Tournefort (1656–1708), a professor of botany and medicine at the University of Montpellier, France, followed Theophrastus in dividing flowering plants into two categories of trees and herbs. Each of these was subdivided into groups based on such characters as flowers petal-bearing or non-petal-bearing, flowers simple or compound (groups akin to the polypetalous and gamopetalous subdivisions of later authors), and flowers regular or irregular. His system was the first to group together as genera the plants we know as oaks, maples, peas, verbenas, and willows. The system was widely adopted in Europe and remained dominant for nearly a century.

A contemporary of Tournefort was John Ray (1628–1705), renowned English naturalist, who devised a classification, based to a large extent on precepts of several earlier botanists, accounting for nearly 18,000 species. It was superior to that of Tournefort in that Ray recognized the monocots as distinct from dicots, separated taxa on the basis of fruit-type (cone-bearing, nut-bearing, berry-producing, pomiferous, pruniferous, etc.) and subdivided these on the basis of leaf and flower characters. It was a system based on the form and gross morphology of plant structures. Unfortunately, it was overshadowed by other systems of the era, and its superior features were unrecognized for nearly a century.

CAROLUS LINNAEUS AND HIS CLASSIFICATION

The great Swedish naturalist and physician, Carolus Linnaeus (1707–1778), was the dominant figure in systematic botany during his time—a dominance that persisted for much of the half-century after his death. At the age of thirty-two he was the author of fourteen botanical works. Among them was his *Genera Plantarum* which was based on his so-called sexual system. It was an artificial system by which all flowering plants were subdivided among twenty-three classes, the first ten containing respectively those plants with flowers having one, two, three, four stamens, etc. Other classes were those whose flowers had stamens that were didynamous, tetradynamous, monadelphous, syngenesious, etc. Each class was subdivided into orders on the basis of the number of styles in each flower.

In addition to providing a numerical basis for classification, the Linnaean system offered a device whereby anyone knowing the fundamental flower structures, and having the ability to count, could identify as well as classify an unknown plant. The system is artificial, because it does not bring related genera—and often related species of the same genus—together. It was not a natural classification nor was it intended to be so.

Linnaeus is remembered also for his famous work, *Species Plantarum* (1753), in which he classified, described, and named every species known to him. It represented the first time that a binomial (the Latin name of a species, composed of two words—the generic name [such as *Quercus*] and the specific epithet [such as *alba*]) was assigned to practically every species of plant known to the author. The importance of this work is made clear in the chapter on Nomenclature.

DE JUSSIEU AND THE PERIOD OF THE NATURAL SYSTEMS

Two members of a family of famous French botanists were Bernard de Jussieu (1699–1766) and his nephew, Antoine Laurent de Jussieu (1748–1836). The first devised and the other improved and published a classification system representing an improvement over that of John Ray, for it utilized such additional characters as ovary position, fusion of floral parts, and types of ovule arrangement. Their thirteen classes of angiosperms have continued to the present to be accepted as valid taxa, sufficient evidence of the keenness of perception evidenced by de Jussieu.

It was Augustin Pyrame de Candolle (1778–1841) who amplified and publicized the basic tenets of the de Jussieu system. This he did in several works, but notably in his monumental *Prodromus systematis naturalis regni vegetabilis*, a seventeen-volume work proposing to classify, describe, and name every species of plant then known. It was never completed for all flowering plants.

The de Jussieu system served as the basis for one that was improved and publicized in English-speaking countries by John Lindley (1799–

1865) in his *Vegetable Kingdom*. It was the first to be widely accepted in Great Britain and America as a successor to that of Linnaeus.

It was not until the British botanists George Bentham (1800–1884) and Sir Joseph D. Hooker (1817–1911) published in three volumes their famous *Genera Plantarum* that the basic concepts of de Jussieu received their highest development. Their *Genera Plantarum* continues to be a standard and much-consulted work, and one whose value is enhanced by our knowledge that the detailed descriptions in it are based on the authors' own meticulous observations of the plant structures and are not copied from previous writings.

These systems, from that of de Jussieu to that of Bentham and Hooker, are called natural systems, because in each case the authors tried to group obviously related taxa together. All of these systems were predicated on the dogma of the constancy and immutability of species, and one represented improvement over another only in degree. All were published in the era prior to the publication of Wallace's and of Darwin's theories of evolution and the origin of species, which automatically closed this period in the history of classification systems and introduced the next.

SYSTEMS BASED ON PHYLOGENY

The publication of Darwin's *Origin of Species* opened a new era in biological thinking. It refuted the dogmas of constancy of species and of the origin of existing species by special creation, and displaced these and related views with theories of descent and evolution. By these theories most biologists hold that existing forms of life are the products of evolutionary processes, and that some combination of characters are the result of gene exchange, and others of mutations.

Recognition of evolutionary forces brought the realization that present-day species of a given genus have a common ancestor, that present-day genera of a family probably are descended from a common ancestor, and that the plants of today are derived from plants long extinct (of which a few are known from the fossil record). This stimulated paleobotanical studies of fossils and allied relics of plants that existed millions of years ago. These studies confirmed some earlier views and gave bases for rejection of others.

A new direction was given to botanical thinking with regard to plant relationships. Botanists were asking, "How are these plants related, . . . from what are they descended, . . . which characters are those of ancestrally more primitive plants and which ones are derived from them, . . . which characters have longest remained unchanged, . . . have characters arisen only once or have some arisen many times independent of one another?" The term phylogeny (meaning "the evolution of a genetically related group of organisms" [Webster]) came into being, and botanists began to rearrange plant families in an effort to place together those families believed to be more closely related to one another, with derivative groups following those presumed to be ancestral. None of these efforts, not even those of the present day, has developed a truly phylogenetic system. One reason is that not enough is known of prehistoric forms to enable the botanist to know, from the evolutionary standpoint, which characters reflect primitive and which reflect advanced conditions. However, this revolution of thinking has resulted in a score or so of different classification systems for higher plants. A few are well known and adopted in various countries, others are known locally, and some have been accepted by few except their authors.

American floras and manuals are based, for the most part, on one or another of three systems of classification—or of recent modifications of them. They are the systems of Engler, of Bessey, and of Hutchinson. Contemporary systems in some European countries are those of Professor Pulle of Utrecht, and of Professor Skottsberg of Stockholm. Most British floras continue to follow the Bentham and Hooker system of classification.

The Engler System

The dominant system of classification in North America today continues to be that proposed over sixty years ago by Adolph Engler. It is the basis for arrangement of families of higher plants in manuals and floras such as those by Fernald, Gleason, Small, Jones, Rydberg, Abrams, Jepson, and Rehder, and for the arrangement of specimens in the larger herbaria of the country.

The widespread acceptance of the Engler system has not resulted from its correctness—it was not an original work, nor are its major tenets accepted today, to even a substantial extent—but rather from the systematic thoroughness with which Engler and his colleagues applied the system to the flora of the world. In his first major work, using this system, he applied it to the classification of all the families of plants and their genera. This work, called *Die natürlichen Pflanzenfamilien,* was published under the joint editorship of Engler and his colleague, A. Prantl.

It is in twenty volumes and accounted for all the genera of algae, fungi, bryophytes, and higher vascular plants then known for the world. Each genus is described, accounted for in keys, and many are well illustrated. This is the last work of its scope to account for the world's flora at the generic level. The system has been revised from time to time by the

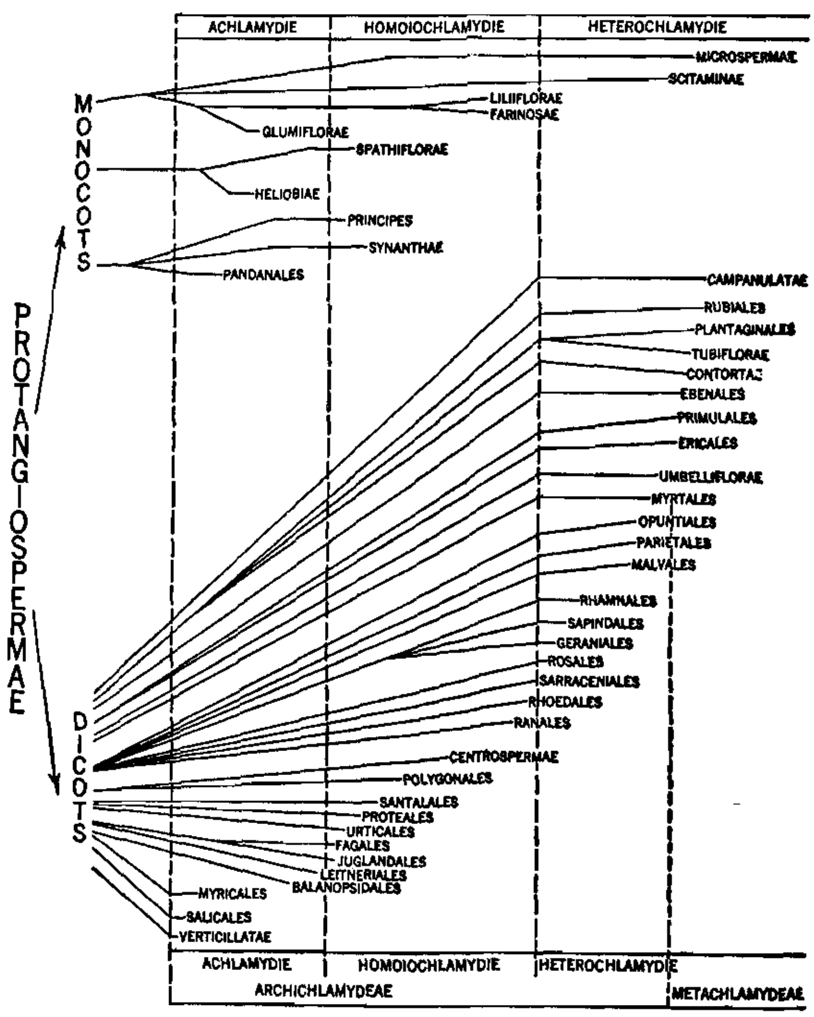

Fig. 1. Classification of the angiosperms, after Engler.

publication of a *Syllabus der natürlichen Pflanzenfamilien*, a single volume accounting for the families of all these major groups but lacking detailed review of the genera and their components. Each revision of the *Syllabus* has held to the major tenets of the Engler system, and no recognition has been given to evidence in support of changes of the basic framework.

Engler's system, based largely on an earlier and little-known system by Eichler (1883), divided plants among four divisions: the algae and fungi, the mosses and liverworts, the ferns, and the seed plants. The last was subdivided into the gymnosperms (cycads, ginkgo, conifers) and the flowering plants (composed of the monocotyledoneae and dicotyledoneae). In the classification of the dicot families, the most primitive were considered to be those families whose flowers had no petals (the Apetalae, e.g., willows, birches, oaks), secondly those families whose flowers had separate petals and sepals (the Choripetaleae, e.g., buttercups, chickweeds, roses, violets, cacti), and lastly those families whose flowers had the petals and the sepals united to varying degrees in two separate perianth units (the Metachlamydeae, e.g., primulas, borages, mints, cucurbits and daisies). Basically, Engler followed the belief that flowers now appearing simple had always been simple, a view rejected by most present-day botanists.

Much has been learned about plants since the time of Engler, and it is now generally accepted that his system is not based on the best evidence. Its present position springs from the reluctance of taxonomists to change today for a system that may be subject to displacement tomorrow. Nonetheless, such a change is overdue and is to be expected. By modern views the Engler system is archaic. The peak of its utility is past.

The Bessey System

Charles Bessey, for many years head of the botany department at the University of Nebraska, was the first American to devise a system of classification. It was, in its latest revision (1915), a modification of the Bentham and Hooker system, but it reflected to a marked degree the influence of evolution on the thinking of that day. The system, despite its obvious merits, has suffered from lack of publicity.

Bessey took many of his basic ideas from de Jussieu, from de Candolle, from Lindley, and perhaps some of them from his contemporary German botanist, Hallier. In his system he attempted to collate what he thought to be the best of these systems (including adoption of some Englerian principles). The arrangement does not differ so much from

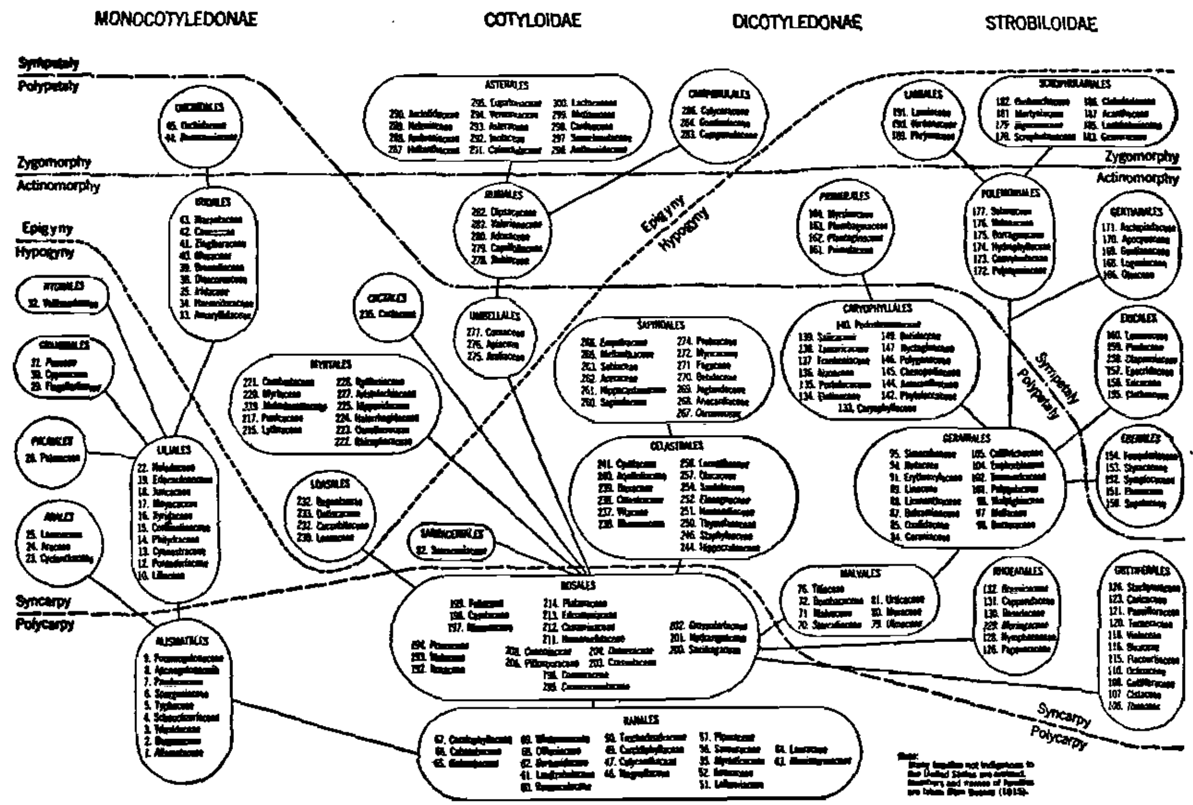

Fig. 2. Classification of the angiosperms, after Bessey, 1915. Arranged by J. F. Cornman.

that of Bentham and Hooker or from that of Engler, as the latter two differ from each other.

According to Bessey's system, the seed plants are composed of three phyla: angiosperms, gymnosperms, and the extinct seed-ferns (Pteridospermae). Only the angiosperms were treated by Bessey, a taxon[1] he considered to be derived from the cycads. He interpreted the strobiloid type of flower, with many spirally arranged parts (e.g., that of magnolia) to be primitive and flowers showing fusion of unlike parts (as corolla and calyx to ovary, in most kinds with an inferior ovary) to be more advanced; those showing fusion of like parts (e.g., petals fused to form a one-piece corolla) and those whose flowers show both types of fusion he considered to be the most highly advanced of all.

The Bessey system is little known outside the United States, and for several reasons: it has never been applied to the world's flora; it has not been championed in recent time by an influential school of taxonomic study; and it has not been revised in the light of recent knowledge. This third factor is probably responsible for the limited acceptance of the system today in this country. While many botanists recognize its good points and accept it as being closer to a realistic phyletic classification than any other system, they also know that many of the family relationships embodied in it are contrary to present evidence. A critical and documented revision of this system, accompanied by its association with the classification of other segments of the plant kingdom and application to the world's flora may produce a more acceptable arrangement than any now available.

The Hutchinson System

John Hutchinson, now retired from the staff of Britain's Royal Botanic Garden at Kew has published a system of classification (1926–34) based on many of the same principles adopted earlier by Bessey but differing in two fundamental respects. One point of divergence is his belief that the dicotyledonous plants represent two distinct subgroups: the *Herbaceae*, composed of families whose members are fundamentally and predominantly herbaceous, and the *Lignosae*, composed of families whose members are fundamentally and predominantly woody. The

[1] The term *taxon* (plural, *taxa*) is of recent widespread usage in botanical literature, although coined and introduced about a quarter-century ago. It is used to designate any taxonomic entity or group without indicating the category to which it may belong. It is the plant, the population, or any number of populations that is the taxon—not the unit of species, nor of genus, or any other category. For example, the taxon Gleason called *Arabis Shortii* was treated by Fernald as *Arabis perstellata* var. *Shortii*.

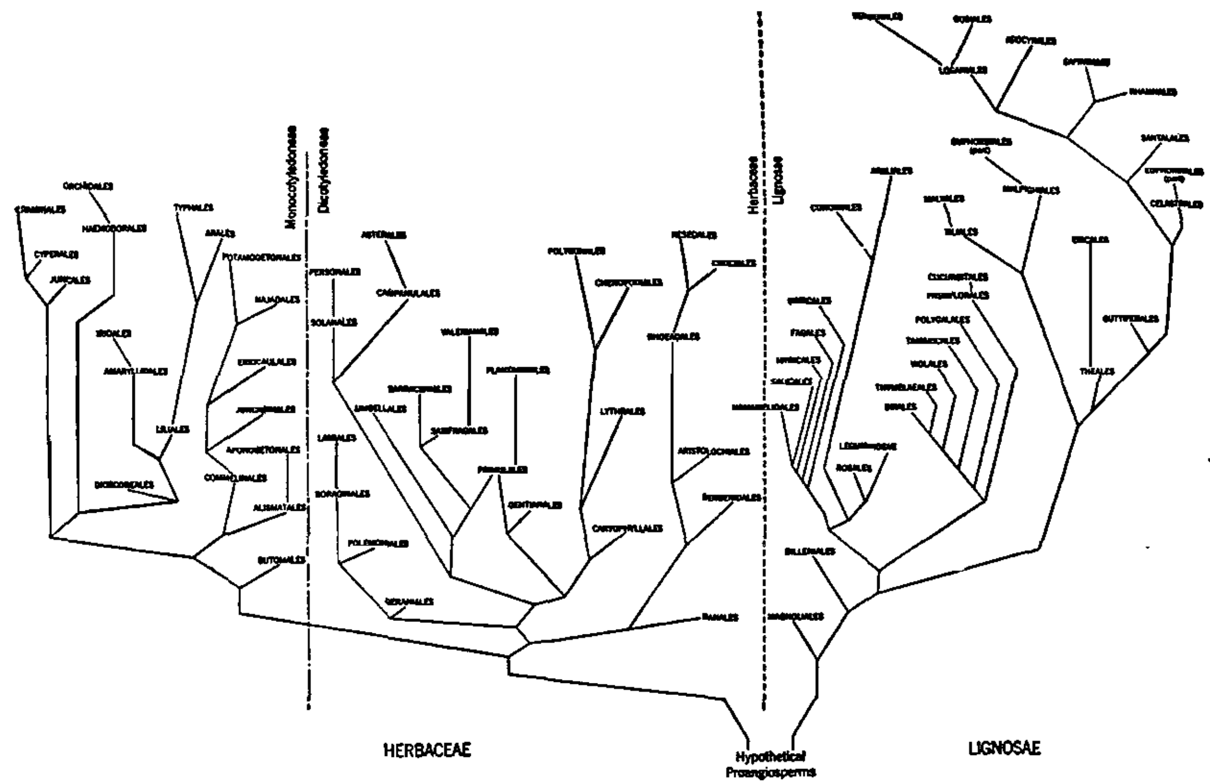

Fig. 3. A classification of the angiosperms. Adapted from Hutchinson, *British Flowering Plants*, P. R. Gawthorn, Ltd., 1948.

second departure from the Bessey system is Hutchinson's defendable view that families with corollas of fused petals have not had one or a few common origins but have evolved independently of one another and thus do not represent a single advanced level.

The Hutchinson classification of the monocots has been viewed more favorably in America than has his treatment of the dicots. For the dicots and the monocots, he has treated the families of the world, but in neither case has he presented reasons for his alignments, nor is there evidence that he gave consideration to available morphological, anatomical, and cytological findings. This system, by its critical appraisal of family relationships and by the excellent keys published with it, has provided more grounds for discussion and greater stimulation of thinking along phyletic lines during the last two decades than has any other.

No floras, except those by Hutchinson, have been based on this system of arrangement, although one book devoted to American wild flowers has adopted it.

Other Systems

The systems encountered in American herbaria, manuals, and floras have been described briefly. There are other systems used currently to a limited extent in other countries. These include the earlier system by Wettstein of Vienna (a modification of the Engler system and in many respects an improvement over it), that by Pulle of Utrecht (a contemporary system little known in America but deserving of greater consideration), that by Skottsberg of Goteborg (a modernization of Wettstein's system), and a few less well known systems.

In 1942, Professor Oswald Tippo, of the University of Illinois, proposed in very broad outline a classification of the plant kingdom based largely on anatomical and morphological criteria. By this system the vascular plants were subdivided into four subdivisions of the phylum Tracheophyta, with the last composed of the three classes indicated:

- Psilopsida
- Sphenopsida
- Lycopsida
- Pteropsida
  - Filicinae
  - Gymnospermae
  - Angiospermae

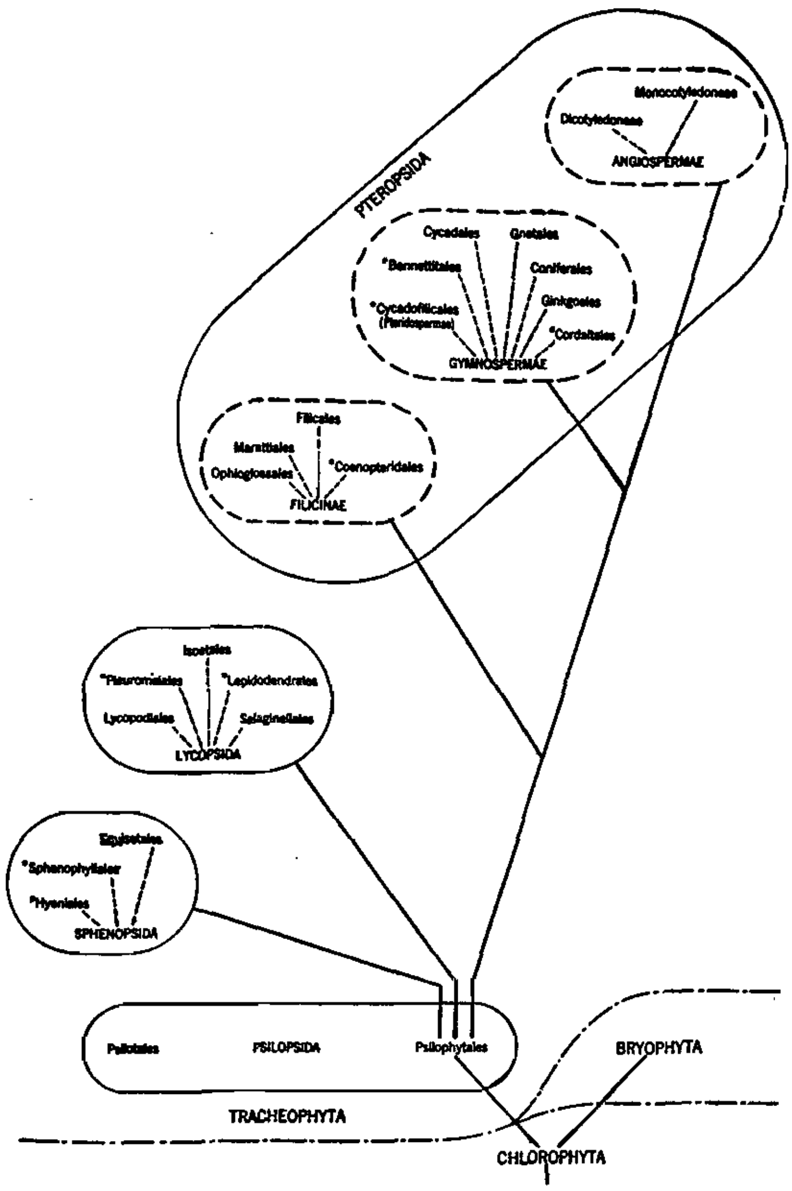

Fig. 4. Classification of the angiosperms, adapted from Tippo (1942). Extinct taxa are marked by an asterisk. The Bryophyta and Chlorophyta (algae) are non-vascular cryptogams.

Unfortunately for taxonomic usage, Tippo did not elaborate his system below the level of the monocots and dicots. No classification was indicated for the families of these groups.

From this brief review, the query may be raised, "What is the correct system of classification?" The answer, and one so common to many biological situations, is that there is none. Classifications are embodied in the taxonomy books one uses—the floras, manuals, monographs, and revisions. Current teaching practices in the United States reflect the adoption to an increasing extent of the Tippo classification, with many authors filling in the gaps for the flowering plants with adaptations from the Bessey system. This is especially true in current books and courses dealing with elementary botany, where a trend set by morphologists seems certain to exert an influence in taxonomic works of the future.

CHAPTER III. Evolution and Units of Classification

EVOLUTION, in the field of biology, is the doctrine which holds that present species of living organisms have descended from more primitive ancestors and that through successive generations—perhaps tens of thousands of them—a series of modifications has occurred. These modifications, or changes in form and function, have been brought about by various means, including natural selection, hybridization, and mutations.

The mechanism of natural selection may be illustrated in its simplest form by the following sequence of events. Assume that a number of individuals of the same parentage occupy a given area and that they produce offspring by sexual reproduction. Assume further that there are some genetical differences among these individuals; no two sexually reproducing individuals are exactly alike. Natural selection acts on this variability. It works in the direction of adaptation, for some of the variations may be toward qualities or characters that better enable the individual to compete and succeed over others or may enable it to grow, reproduce, and invade areas where conditions are favorable or unfavorable with respect to members of the initial population.

Hybridization is the crossing of two genetically different individuals by the fusion of gametes. It is considered that some present-day species originated—probably thousands of years ago—by the hybridization of two other species now extant. Products of this kind of evolution perhaps include such well-known plants as timothy (*Phleum pratense*), annual bluegrass (*Poa annua*), tobacco (*Nicotiana Tabacum*), the common plum (*Prunus domestica*), and *Spartina Townsendii.*

Mutations result from changes in the molecular structure of the gene, and these changes are reflected in the characters which the genes control. Mutations may affect major or minor characteristics. These changes are heritable and are transmittable from generation to generation.

It was once believed that evolutionary changes were caused directly by changes in environment, as for example, when a habitat gradually became more desert-like, the structures of some of the plants growing in it were modified, and their descendants became adapted to the new environment, or that organs or structures were changed by use or disuse on the part of the individual. This belief, known as Lamarckism, is not now generally accepted.

Following the work of Lamarck, and as a product of studies by Darwin, there came into more general acceptance the belief that evolution results from the transmission of variations from parent to offspring. Mendel demonstrated that characters among hybrids are inherited in certain predictable ratios.

Following the reasoning presented above, it is now generally held that existing species have been produced through evolutionary processes. Several related species may have had a common ancestor. These several species may compose a genus, in which case this common ancestor was that of the genus. Perhaps another allied genus also had a common ancestor. If the two ancestors of the genera in question came from the same stock, it could be said that those genera and their species had a *monophyletic* origin (at least back to the level under discussion). This implies a forking or branching type of ancestry. Some botanists carry this concept to the extent of believing that the dicots as a taxon, or the monocots similarly, had a monophyletic origin; others extend it to the angiosperms, while there are authors who have postulated that all plant life has arisen from a single unicellular individual. Few botanists today hold these extreme views of development by monophyletic lines. The greater number of botanists, while accepting monophyleticism for groups of species, genera, and even for some families and orders, consider the major taxa to have had *polyphyletic* origins; that is, groups now considered a part of the same taxon are presumed to have evolved from several ancestral forms. The features in common of taxa within these major units are believed to represent the result of convergent evolution. In other instances, selected characters (such as the inferior ovary, or the gamopetalous corolla) have arisen in different genera and families (and even in different orders) by what is termed as parallel evolution. That is, characters resulting from parallel evolution did not have a common ancestor responsible for that character; they do not express a monophyletic origin.

Regardless of the type of origin (monophyletic or polyphyletic), it is accepted that some groups of species are more closely related to one another than to species within other groups. Several species, comprising a genus, may have had a common ancestor (possibly extinct). These units of classification—species, genus, family, etc.—are assumed to be natural units in that they are genetically related. Because of this genetical relationship, some genera are more distinct than are others; sometimes they are distinct, but in other instances a group of allied genera may lack fixed limits or boundaries (in which cases, authors may not concur on the number of genera involved).

To a lesser extent the same situations prevail at the lower level of the species. There is no universally accepted definition of what a species is. Despite the convictions and efforts of some geneticists, the determination of species limits or circumscription is a matter of opinion—an opinion based on knowledge of the components of a group, on judgment, and on taxonomic competence. These differences in interpretation account for the fact that the late Professor Fernald recognized nineteen species of Juneberry (*Amelanchier*) for northeastern North America, while Gleason recognized eight species of the same genus for approximately the same area. This exemplifies the difference in judgment of the same data by two eminent taxonomists and illustrates the extent of individual opinion in taxonomic studies. It cannot be said that one author is right and the other wrong. Each is entitled to his own opinion. The student may accept one or the other or reject both in favor of still other views. Such is the freedom requisite to all scientific work in the field of biology.

The *units of classification* and their sequence of relationship are established by the International Code of Botanical Nomenclature (cf. Chapter VI, pp. 90–91). The plants of the world compose the vegetable kingdom (as opposed to the animal kingdom). This, the largest unit, is subdivided into successively smaller units, as follows (examples based on the Tippo system of classification):

Division (sometimes, but not legitimately, designated Phylum)—example: *Tracheophyta* (the vascular plants).
- Subdivision—example: *Pteropsida* (the ferns and seed plants)
  - Class—example: *Angiospermae* (the flowering plants)
    - Subclass—example: *Dicotyledoneae*
      - Order—example: *Rosales*
        - Family—example: *Rosaceae*

Subdivisions of family include: subfamily and tribe, each composed of one or more genera

Genus—example: *Rosa*. Subdivisions of genus include: subgenus, section, subsection and series, in that order. These are only of taxonomic significance to show affinities of included species.

Species—example: Rosa setigera

Varietas

Forma

Clone

The Latin names given to taxa in the highest four units of classification vary with the system followed, but the names and sequence of the units themselves (as division, class, etc.) are always the same. This is illustrated in Table I. From this table, it will be noted that, except for Tippo's system, the taxa are retained in the same categories but sometimes are given different names. The system of Tippo, in which the vascular plants [the ferns and the seed plants] compose a single category (a division), shifts the taxon Dicotyledoneae from the category of class to subclass. Note, however, that the sequence of the units remains the same. The shift in taxonomic emphasis reflected by this system is an expression of the author's opinion. Many contemporary authors believe that there are no discrete taxa intermediate between the Dicotyledoneae and the orders that compose them (a current view in opposition to that held a half-century and more ago). Certainly there is little evidence to support the taxonomic validity of the subclasses accepted by Bentham and Hooker and by Engler (shown in Table I).

Table I. Names given to major units of dicotyledonous plants by various authors.

AUTHOR OF SYSTEM	DIVISION (Phylum)	SUBDIVISION	CLASS	SUBCLASS
Bentham and Hooker	Phanerogamae	Angiospermae	Dicotyledoneae	Polypetalae
Engler	Embryophyta Siphonogamara	Angiospermae	Dicotyledoneae	Archichlamydeae
Bessey	Phanerogamae	Anthophyta	Alternifoliae	Strobiloideae
Tippo	Tracheophyta	Pteropsida	Angiospermae	Dicotyledoneae

The category of *order* stands below that of class (and subclass) and above that of family. Names of orders end in *-ales*, such as Ranales and Rosales. Generally, an order is composed of several families, such as the

Rosaceae, Saxifragaceae, and Crassulaceae, included among those placed in the Rosales. The components of an order usually are bound together, or have in common, one or more phyletically important characters. Some orders contain only a single genus, one that is so distinct from all others as to comprise not only a family by itself, but a separate order (e.g., *Ginkgo* of the Ginkgoales, *Welwitschia* of the Welwitschiales, and *Casuarina* of the Casuarinales).

The *family* is the largest category commonly encountered in routine taxonomic work. It is usually a readily recognized taxon composed of one or more genera whose similarities are greater than their differences. Names of families end in *-aceae*, with the exception of eight families whose names end in *-ae*. However it is admissible to use alternative names ending in *-aceae* for those eight exceptions and an increasing number of authors have adopted the alternative names. These eight families and their alternative names are:

Gramineae	=	Poaceae	Guttiferae	=	Clusiaceae
Palmae	=	Arecaceae	Umbelliferae	=	Ammiaceae
Cruciferae	=	Brassicaceae	Labiatae	=	Lamiaceae
Leguminosae	=	Fabaceae	Compositae	=	Asteraceae

A family is often distinguished by characters of reproductive structures (e.g., the fruit in such families as the Aceraceae [samara], Umbelliferae [schizocarp], Leguminosae [legume, loment], and Cucurbitaceae [pepo], or the inflorescence in the Gramineae [spikelet], Fagaceae [ament], Amaryllidaceae [umbel], and Compositae [head]), or by combinations of these and other characters.

The *genus* is often recognizable by one or more characters of gross morphology. The names of genera are nouns from any source whatsoever. They may be masculine, feminine, or neuter in gender and may be in Latin or Latinized derivatives from the Greek.

The *species* (abbreviated *sp.* when singular and *spp.* when plural) is the basic unit of classification. A *species name* is composed of two words, the generic name plus a specific epithet, such as *Rosa gallica*. The species name is sometimes designated the *binary name* or the *binomial*, and the species epithet (e.g., *gallica*) the binary or specific *epithet*. Specific epithets are ordinarily spelled with a small initial, but in much of the literature certain specific epithets may commence with a capital initial (when named for a person, when commemorating a generic name, when a noun in apposition, and when commemorating a barbaric name). The practice of capitalizing certain specific epithets is now optional, with an increasing number of authors decapitalizing all specific epithets.

Infraspecific units of classification are those whose rank is below that of species. A *subspecies* (abbreviated *ssp.* or *subsp.*) is that category immediately below species. It is variously defined; by some authors it is a "baby species" or an "incipient species" (one whose evolutionary development has not progressed to the extent of its being markedly and consistently distinct from its parent species), by others the subspecies is a subdivision of a species having its own distribution but not sufficiently distinct (morphologically or genetically) to deserve elevation to the rank of species. A *varietas* (more commonly known in this country by its English name *variety*, and abbreviated *var.*) is a unit subordinate to the subspecies when the latter category is used (otherwise it is subordinate to the species) and like the subspecies is subject to varying definitions. The *varietas* of some authors is treated as subspecies by others. A *forma* (abbreviated *f.*) is a minor variant (the variation perhaps often caused by a single gene difference, or distinguished by a single character) of a species or higher infraspecific unit, and one lacking constancy and usually occurring sporadically in random populations (such as albino forms, or forms differing in vestiture, or minor leaf character). The *clone* (abbreviated *cl.*) is a vegetative propagule, an individual; generally the term is reserved for individuals of horticultural value (e.g., the so-called garden "varieties" of rose, iris, gladiolus, etc.). The *apomict* is genetically the same as a clone. It is a plant grown from a seed which has developed from an ovule that was not fertilized. It contains no paternal germ plasm and is the cytogenetic equivalent of its "mother."

In considering these units of classification, *it is important* to remember their sequence of arrangement, to remember that a class is composed of one or more orders, an order of one or more families, a family of one or more genera, and a genus of one or more species. The student unfamiliar with Latin must remember that the plural form of the word species is no different from the singular form but that the plural form of the word genus is always genera. It should also be remembered that the ending for family names is *-aceae* and for that of order is *-ales*. The botanically trained ear becomes tuned to spot the name of a family immediately by association of that ending *-aceae*, and of the next higher category, order, by association of the ending *-ales*.

The study of evolution soon becomes complex and technical and, when pursued, leads one to the related fields of genetics and cytogenetics.

The student should not be disturbed or unduly confused over matters of phylogeny and the evolution of present-day plants, but he should find solace in the knowledge that even specialists are no more than intelligent speculators, arriving at conclusions with a minimum of evidence. Because of the lack of knowledge with regard to the sequence of events in the far distant past, the evidence is not now at hand on which to base dependably any phylogenetic system of classification. The student should view any new system of classification with an open mind, knowing it is unlikely to be the ultimate, and should be prepared to accept its later rejection for another. These systems may reflect stages or levels in the increase of knowledge, and as such each plays a contributory role to be welcomed and not decried.

CHAPTER IV. *Plant Structures*

PLANT IDENTIFICATION is based on one's ability to recognize the characters by which one kind of plant may be distinguished from another. This requires a knowledge of plant structures and a familiarity with the names by which they and their components are known. The terminology employed in any manual, flora, or plant dictionary is extensive. The names or terms used may seem unduly technical, alien to one's vocabulary, and in the aggregate may (and sometimes do) contribute to a jargon that is almost meaningless to the non-botanist. Nonetheless, these terms do give precision to expression, they are concise, and they are a part of botanical literature.

The greater the scope and detail of a flora or manual, the more technical it is likely to be. One of the ways to comprehend this technical jargon is to take the time to study and comprehend the gross morphology of a plant, to understand the relationships of its parts, and to know the terms applied to them. These terms are often in polysyllables and, like the scientific names of most plants, are generally taken from the Latin or Greek. A knowledge of one or both of these languages may facilitate understanding the terminology, but it is not a prerequisite. A technical terminology becomes essential when precision and exactness are required. It enables a writer to express much with a single word. Botanical terminology has a heritage and has developed over the centuries. When provided with a knowledge of botanical terms and the barest minimum of Latin grammar, anyone can read or comprehend a Latin description of a plant.

This book treats the vascular plants: the ferns and lycopods, the gymnosperms, and the angiosperms. The gross structures of each are markedly different, and, in general, each has its own terminology. For this reason the morphology and terminology peculiar to each major group is taken up separately.

VASCULAR CRYPTOGAMS

The vascular cryptogams include the three subdivisions *Psilopsida* (*Psilotum*), *Sphenopsida* (horse-tails), *Lycopsida* (Club-mosses), and the class *Filicinae* (true ferns) of the *Pteropsida*. These are spore-producing vascular plants. They do not produce flowers, fruits, or seeds.

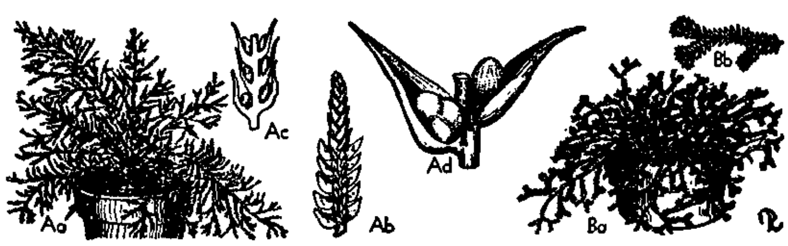

Fig. 5. SELAGINELLACEAE. A, *Selaginella pallescens:* Aa, habit of plant; Ab, branch tip; Ac, fertile branch, vertical section; Ad, same, showing megasporangium (left) and microsporangium (right). B, *Selaginella Kraussiana:* Ba, habit of plant; Bb, branch tip. (From L. H. Bailey, *Manual of cultivated plants*, The Macmillan Company, 1949. Copyright 1925 and 1949 by Liberty H. Bailey.)

A *spore* is a simple reproductive body, usually composed of a single detached cell, and contains a nucleated mass of protoplasm (but no embryo) that is capable of germinating and developing into a new individual. In the vascular cryptogams, the spore germinates and produces a tiny, independent, usually green, flattened thallus, the *gametophyte*. The gametophyte is so small that most persons never notice it in nature. It bears sex organs (of one or both sexes), and from the fertilized egg of the *archegonium* (the female organ) is produced the familiar conspicuous plant. In contrast to the gametophyte, it is called the sporophyte. The sporophyte is the usually foliaceous spore-producing plant. In most ferns the spores are alike, and the species is said to be *homosporous*. In other vascular cryptogams (e.g., *Selaginella*, Fig. 5; *Isoëtes*, Fig. 6; and *Salvinia*, Fig. 7), two kinds of spores are produced, and the species is said to be *heterosporous*. These two kinds are *microspores* that on germination produce antheridia-bearing (male) gametophytes, and *megaspores* that on germination produce archegonia-bearing (female) gametophytes. The surface of spores may be variously pitted, net-like, knobby, or spiny—features that may provide characters for identification.

Spores are borne in cases called *sporangia*. These are of many types and shapes (Figs. 8 f, g, h). In the *Filicinae*, or true ferns, the sporangium may bear a ring or cluster of thick-walled cells, the *annulus*, and is then said to be *annulate* (Fig. 8 f showing an incomplete and vertical

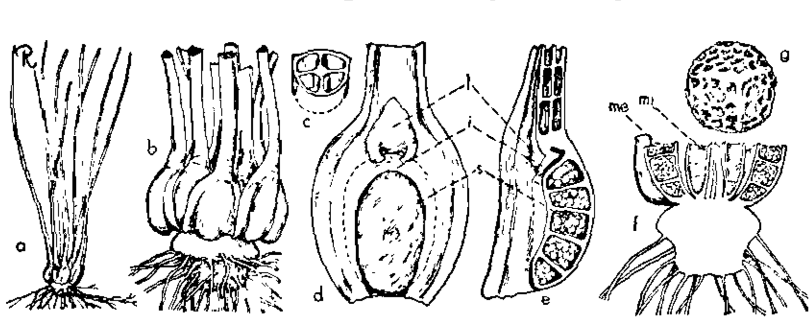

Fig. 6. ISOETACEAE. *Isoetes Engelmannii:* a, plant, habit; b, corm, with attached leaf bases; c, leaf, cross-section; d, leaf base, ventral side; e, leaf base, vertical section; f, corm with portion of leaf bases, vertical section; g, megaspore. (i, velum; l, ligule; me, megaspores; mi, microspores; s, sporangium.)

annulus, Fig. 8 h showing a complete and apical annulus) or no annulus may be present (Fig. 8 g). The sporangium may be stalked (Fig. 8 f) or sessile (Fig. 8 g). Its mode of *dehiscence* or opening may be transverse (Fig. 8 f) or by a terminal slit (Fig. 8 i).

Fern sporangia may be scattered over or may densely cover the under

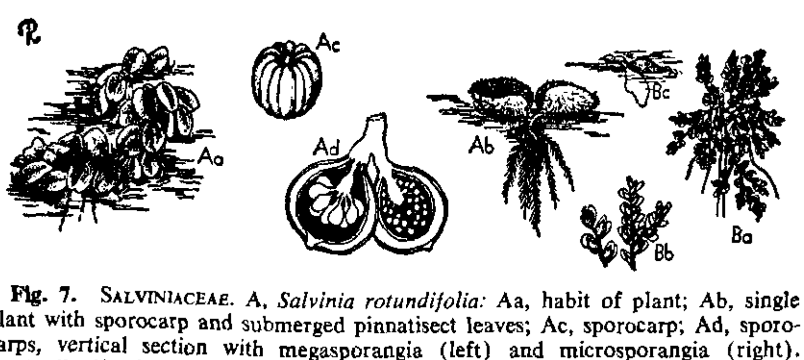

Fig. 7. SALVINIACEAE. A, *Salvinia rotundifolia:* Aa, habit of plant; Ab, single plant with sporocarp and submerged pinnatisect leaves; Ac, sporocarp; Ad, sporocarps, vertical section with megasporangia (left) and microsporangia (right). B, *Azolla filiculoides:* Ba, habit; Bb, sterile branch; Bc, leaf. (From L. H. Bailey, *Manual of cultivated plants*, The Macmillan Company, 1949. Copyright 1924 and 1949 by Liberty H. Bailey.)

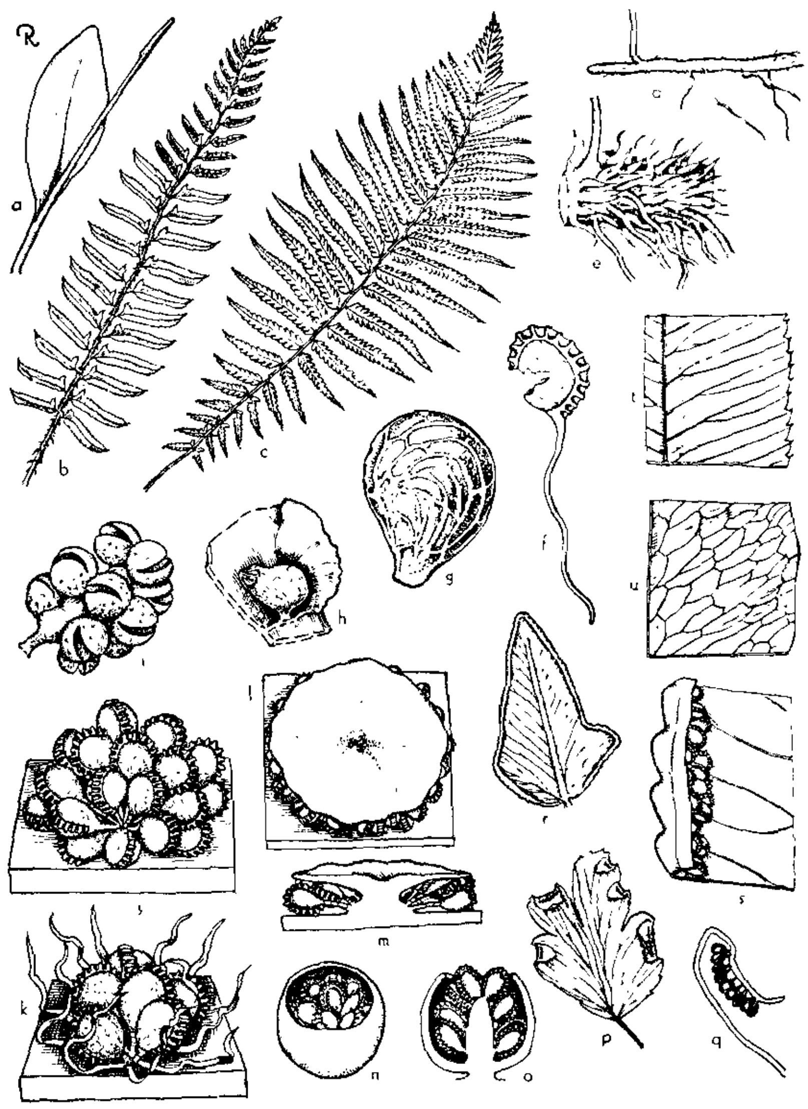

Fig. 8. FILICINAE: a, simple leaf-blade; b, one-pinnate leaf; c, one-pinnate leaf, the pinnae one-pinnatifid; d, naked rhizome; e, scaly rhizome; f, sporangium with incomplete annulus; g, sporangium; h, sorus, single sporangium; i, segment of fertile frond; j, naked sorus; k, sorus subtended by lacerated indusium; l, sorus, indusium peltate; m, same, vertical section; n, sorus, indusium cup-shaped; o, same, vertical section; p, sorus a marginal flap; q, same, vertical section; r, sorus marginal, contiguous; s, same, much enlarged; t, veins dichotomous and free; u, veins anastomosing and reticulate.

(dorsal) side of a leaf. More often they are arranged in tiny distinct clusters called *sori* (sorus, the singular form). The sorus may be subtended, surrounded, or more or less covered by an *indusium*. This indusium may be *superior* and umbrella-like (*peltate*) (Figs. 8 l, m), or it may become slit or opened towards the central stalk and is more or less horseshoe-like. It may be *inferior* and cuplike (Figs. 8 n, o), or it may be inferior and shield-like (the shield may be segmented into ribbons as in Fig. 8 k). In some sori the indusium is a marginal flap of the leaflet (Figs. 8 p, q, s). When the sorus has no indusium it is said to be *naked*. However, by the time the indusiate sporangium is fully developed, the indusium is often shrivelled and may have lost its characteristic form. For this reason, whenever possible, examination should be made of a series of sori of varying degrees of development to determine more accurately whether or not an indusium is present and what are its characteristics.

The position and arrangement of sori are of taxonomic importance. Sori may be distributed over the dorsal surface of all leaflets or only on the more terminal leaflets (Fig. 8 b). In some taxa they are in a row, and when so close together as to touch one another and appear as if one "long sorus" are said to be *confluent* or *contiguous*. These rows may be *marginal* (Figs. 8 r, s) or may extend along the mid-vein or a lateral vein.

The vegetative structures of ferns are of equal importance to identification. This is more true when engaged in field studies than in critical revisionary studies. The habit of growth is important. Except for the exotic and subtropical tree-ferns, the stems of most ferns are rhizomatous—although some ferns are climbers by the production of slender stem-like leaves. These rhizomes may be *scaly* (Fig. 8 e) or *naked* (Fig. 8 d). Sometimes when scaly, or woolly, the vestiture (covering) extends to the leaves. Often the rhizomes are *creeping*.

Fern leaves provide many taxonomic characters. They are usually *circinate* in vernation. That is, they are usually rolled coil-wise in bud from the top downward, with the apex nearest the center of the coil. Young circinate fern leaves just beginning to expand are sometimes called *fiddleheads* or *crosiers*, from their resemblance to those objects. In much of the literature, fern leaves are designated *fronds*, a term applied also to the compound leaves of cycads and palms. There is no structural difference between a leaf and a frond.

A fern leaf may be *simple* or *compound*. When simple, it consists of a *blade* and a stalk or *petiole* (sometimes termed the *stipe*). The blade of a simple leaf may be *entire* (as is the leaf-blade of lilac or grass) or it may be variously toothed, lobed, or dissected. When a portion of the tissue of adjoining lobes or segments of a deeply divided leaf extends along the mid-vein and connects one segment of the blade with another, that leaf is considered simple.

A fern or other leaf is compound when the segments are completely separate (Figs. 8 b, c). Each segment is a *leaflet*. In fern literature the leaflet is commonly called a *pinna*. That portion of the axis of a compound leaf from the lowest pair of *pinnae* upwards is termed the *rachis*. A leaf with one rachis and a single series of pinnae is *one-pinnate* (Fig. 8 b). In some ferns each pinna is compound and its mid-vein bears pairs of lateral secondary leaflets called *pinnules*. Such a leaf is *two-pinnate* or *decompound* (Fig. 13 f) and some decompound leaves are *three-pinnate* or more (Fig. 13 g).

In most ferns the leaves of a given plant are more or less alike. When sporangia are present the leaf is said to be *fertile*, when not present it is said to be *sterile*. In a few genera or families the plants produce some leaves that remain sterile and others that become fertile. When the fertile leaves are dissimilar to the sterile ones, the leaves of that plant are called *dimorphic*. Leaf dimorphism may be represented by the fertile leaves oı segments conspicuously narrower, bearing abundant and often densely congested sporangia. In the more extreme examples, one part of the leaf may be foliaceous and another reduced to an apparent axis covered with sporangia.

The *venation* (arrangement of veins) of fern leaves is of taxonomic significance. In some ferns, the veins branch by forking successively in pairs, a type of branching termed *dichotomous* (Figs. 8 p, r). The veins may extend to the margins, not uniting with others, and are *free* (Fig. 8 t), or they may *anastomose* (connect with one another) to form a network, and the venation is *reticulate* (Fig. 8 u). The meshes of such a network are called *areoles*.

Explanations and illustrations of terms of vestiture, leaf form, margin, and texture are to be sought in the section of this chapter devoted to the angiosperms.

GYMNOSPERMS

The gymnosperms, together with the angiosperms, compose the present-day group known as the seed plants. The seed plants (sometimes designated as phanerogams or spermatophytes) differ from the vascular cryptogams in that the gametophyte is reduced to a comparatively few cells, always enclosed within sporophytic tissue, and is never an independent body. Two other distinguishing characteristics are the formation of pollen tubes (from the pollen grains) and the production of seeds.

In the gymnosperms, represented by the cycads, ginkgo, conifers, and ephedra, the female element is the *megasporangium* (ovule) and the male element is the *microsporangium* (pollen grain). Each type is borne on the surface of a *megasporophyll* and a *microsporophyll* respectively. In the gymnosperm megasporangium, the outer tissues are those of the sporophyte and consist of the *integument* and *nucellus*. At the tip is a minute opening, the *micropyle*. Within the nucellus is the *female gametophyte*. At the upper end of this gametophyte, and directly below the micropyle, two or more *archegonia* are produced. Each archegonium contains one egg-cell which, after fertilization, develops into the embryo within the new seed. Because of their minuteness, none of these characters is of everyday use in identification of the gymnosperms. They are reviewed here to point out the fundamental differences between gymnosperms and angiosperms and are of vital importance when considering phyletic relationships of families and orders cf gymnosperms.

In ordinary taxonomic studies, the gymnosperms may be distinguished from the angiosperms by the absence of flowers, by the ovules borne naked on sporophylls, and by the seed not enclosed within a fruiting structure of ovarian origin. There are also differences in vegetative anatomy that collectively separate one taxon from the other, notably, in the gymnosperms, the absence of vessels in the secondary xylem and in the presence of resin canals.

The gymnosperms are composed of at least four, and probably six orders: Cycadales, Ginkgoales, Coniferales, and Gnetales (the components of the latter are so divergently different as to be considered by more recent authors to represent three orders—Ephedrales, Gnetales, and Welwitschiales). Each order of gymnosperm is so different from another as to have almost separate terminologies for its distinguishing characters.

The Cycadales contain the one family Cycadaceae, of which only one genus (*Zamia*) is native to the United States. All members of the order have pinnately or bipinnately compound leaves that are *persistent* (the plants are evergreen), remaining on the plant for three to ten years.

The sexes of reproductive organs are grouped separately (the species are dioecious, an individual plant being either male or female). The male organs are borne on a *strobilus* (pl. *strobili*), a cone-like structure (Fig. 9 c) consisting of a central axis about which are many closely packed spirally arranged fertile sporophylls termed *microsporophylls* (Fig. 9 d). Each microsporophyll bears an abundance of *microsporangia* or pollen-sacs on its lower (dorsal) surface (Fig. 9 e). *Pollen grains* produced from these microsporangia are carried by air currents. After a pollen grain comes in contact with the ovule it germinates and produces the *motile sperm* by which fertilization is effected.

In *Cycas* the megasporophylls or ovulate scales are several in number, pinnately lobed, and are arranged in a whorl in the center of the crown of leaves, at the top of the stem. Each bears four to eight erect naked ovules that are about the size of duck's eggs (Figs. 9 a, b). In other genera the ovulate-scales are much more numerous and are spirally arranged on an axis (as are the microsporophylls) and form an *ovulate strobilus* called the female cone.

The Ginkgoales contain a single family (Ginkgoaceae), which is composed of a single genus (*Ginkgo*). The one species (*G. biloba*) is a tree unlike any other gymnosperm. Its leaves are *deciduous*, falling in autumn, and are fan-shaped with dichotomous venation (Fig. 9 f). The species is dioecious (sexes on separate plants, one plant male, the other female). It belongs to the gymnosperms because it produces naked ovules (Fig. 9 f), and its seed is not enclosed by any ovarian structure (Fig. 9 h). The drupelike seed consists of a fleshy outer integument, a hard bony inner integument, and an embryo (Fig. 9 h). As in the cycads, the Ginkgo egg is fertilized by a motile sperm.

The Coniferales are probably the best-known North American representatives of the gymnosperms. They are the cone-bearing evergreens and are represented by the pines, firs, cedars, cypresses, and araucarias plus those not producing cones as the podocarps and taxads (the last two placed in a separate order, Taxales, by some authors). The conifers differ from the cycads and ginkgo in the leaves needle- or scalelike (at least in North American natives), in the pollen not producing motile sperm, and in most genera being *monoecious* (the sexes separate but on the same plant). In most members the scales of the ovulate strobilus (each usually subtended by a bract) become woody at time of seed maturity (leathery in Junipers). The male strobilus is much smaller than the female and is herbaceous in texture. In the primitive families of the order (as in Taxaceae), the male strobilus consists of an axis bearing

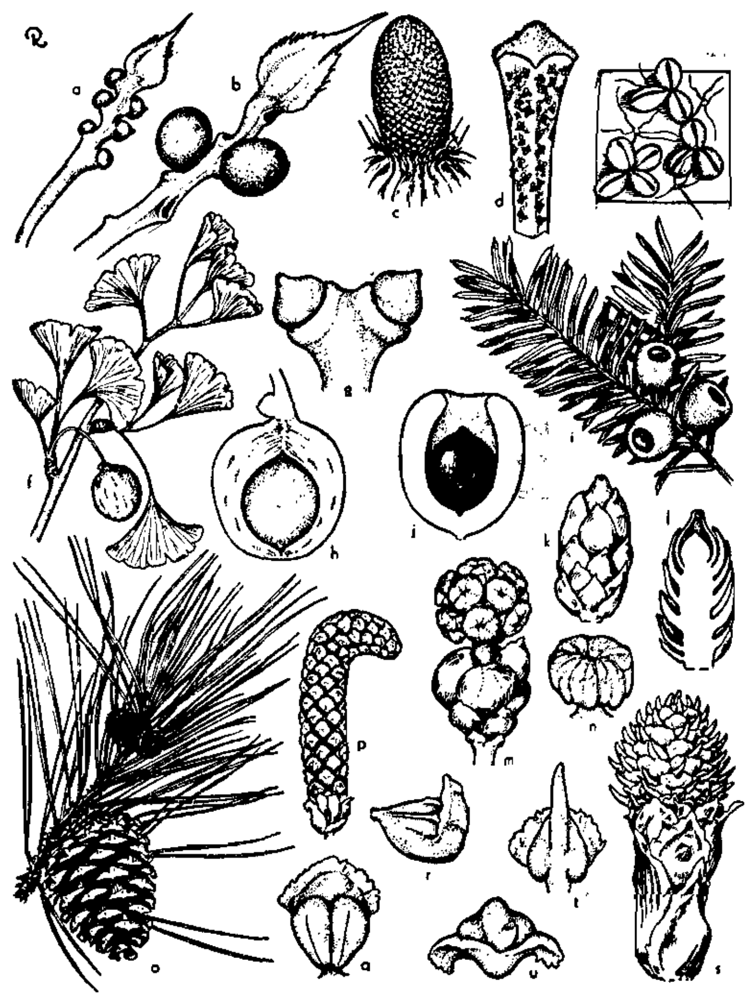

Fig. 9. GYMNOSPERMAE: a, *Cycas*, ovulate sporophyll; b, same, bearing seeds; c, staminate strobilus; d, fertile scale of staminate strobilus, lower surface; e, same, enlarged; f, branch of *Ginkgo* bearing one drupe-like seed; g, *Ginkgo*, ovulate branch; h, *Ginkgo* seed, vertical section; i, *Taxus*, fruiting branch; j, *Taxus* seed and aril (aril in vertical section); k, *Taxus*, ovulate branch; l, same, vertical section; m, *Taxus*, staminate strobilus; n, *Taxus*, peltate microsporophyll; o, *Pinus* branch with one- and two-year-old cones; p, *Pinus*, staminate strobilus; q, *Pinus*, microsporophyll, lower (abaxial) surface; r, same, three-quarter view of adaxial surface; s, *Pinus*, ovulate strobilus; t, *Pinus*, ovulate scale, abaxial surface; u, same, end view.

three to fourteen peltate fertile microsporophylls subtended by several flattened sterile bracts (Figs. 9 m, n), and the ovulate "strobilus" of an axis terminated by a single naked ovule and subtended by sterile scales (Figs. 9 j, k). The seed is solitary but enveloped by a red or purple fleshy aril (Figs. 9 i, l). In the more advanced Pinaceae, the bract subtending each ovulate scale is more or less completely fused to the scale and at maturity the strobilus is a woody cone (Fig. 9 o). In the genus *Pinus* most of the leaves are borne on very short shoots and in clusters (*fascicles*) of usually two to five, depending on the species (Fig. 9 o). The microsporophylls of the male strobilus (Fig. 9 p) contain two pollen-sacs on the lower side (Figs. 9 q, r). The seeds are often winged. In the Cuppressaceae the leaves and cone scales are often *whorled* or *opposite,* and are *decussate* in arrangement (each successive pair at right angles to the preceding pair), with the leaves often small and scale-like.

ANGIOSPERMS

The angiosperms, like the gymnosperms are seed plants, but differ from the gymnosperms in the production of flowers, in the enclosure of the ovule within an *ovary* (and the seeds enclosed within a fruit), and in vegetative aspects of stem anatomy where the wood, in contrast to that of gymnosperms, usually contains vessels and lacks resin ducts. Unlike the gymnosperms, no archegonia are produced within the female gametophyte which, in the angiosperm, consists of an *embryo sac* containing a megaspore nucleus. This nucleus divides three times to form eight nuclei, one of which becomes the egg cell. Following fertilization, by one sperm nucleus from the germinated pollen grain, an embryo is developed.

The angiosperms are composed of two subclasses, the Monocotyledoneae and the Dicotyledoneae. The basic reproductive structures of each of these taxa are similar. In the treatment that follows, the vegetative structures are treated separately from the reproductive. Vegetative structures of stems and leaves are used extensively in plant identification, and in the characterization of many taxa. They may be classified as stems, leaves, and systems of inflorescences.

STEMS

Stems provide many characters and these may be related to (1) axis and habit, (2) direction of growth, and (3) types of modified stems.

The *axis* of a plant is its main stem, as the trunk of a tree or stalk of an herb. The point of origin on that axis of a leaf or bud is a *node*. The span between two adjoining nodes is an *internode*. The angle formed by the axis and leaf is the *axil*.

Any plant producing a conspicuous stem above the ground is said to be *caulescent*, whereas one in which the stem is inconspicuous or seemingly absent (as in dandelion or plantain) is termed *acaulescent*. Many acaulescent plants bear flowers singly or in terminal heads on long leafless stalks known as scapes and are called *scapose* (Fig. 26 a). Plants whose stems are very short, but much branched and usually covered with leaves, often form cushion-like tufts or mounds and are *cespitose*. Those having several stems, or branches, growing close together and upward to give a columnar effect are described as *strict* and in the extreme form are called *fastigiate*. Stems may bend abruptly at the nodes (as in some grasses) and be termed *geniculate*, or may fork successively in equal pairs (as in club-mosses) and be termed *dichotomous*.

In some groups of plants, stems are given special terms, such as *culm* for the stems of grasses, *boles* for the unbranched stems of forest trees, and *caudex* for the stems of woody monocotyledonous plants, such as palms and some aroids.

DIRECTION of stem growth provides a character of aid in field identification. Many of the terms used are common to the ordinary vocabulary but here may have more precise meaning. A stem is *erect* when growing straight upwards, a flower is erect when opening skywards. *Ascending* means arched upward and approaching erect (Fig. 10 a); a *decumbent* habit is when the stem lies flattened immediately above but not on the ground, the branch tips usually ascending, such as in some prostrate junipers (Fig. 10 b); *procumbent* differs from decumbent in that the stem lies on the ground, but does not root at the nodes, e.g., garden weed Purslane (Fig. 10 c); *stoloniferous* applies when the plant sends out leafless runners whose tips root and these produce new plants, e.g., in strawberry (Fig. 10 d) (the term is applied to underground stolons functioning similarly); *repent* is the term for the usual creeping condition, where a stem grows along the surface, rooting at the nodes, such as in Checkerberry or chickweed (Fig. 10 e); *soboliferous* is a growth condition produced when plants (usually trees or shrubs) spread and form clumps by underground rhizomes, e.g., sumac or sassafras (Fig. 10 f).

Plants whose stems are vinelike are called *lianes* (pronounced lie-a yē-ns), and stems of this type also may be termed *scandent*. Those that grow over obstructions, and are without tendrils or other means of self-support, are said to be *clambering,* while others that grow upwards to whatever height the available support or growth limit permits are said to be *climbing.* Climbing lianes may derive their support by the stems *twining* about an axis, such as wisteria; by means of modified structures

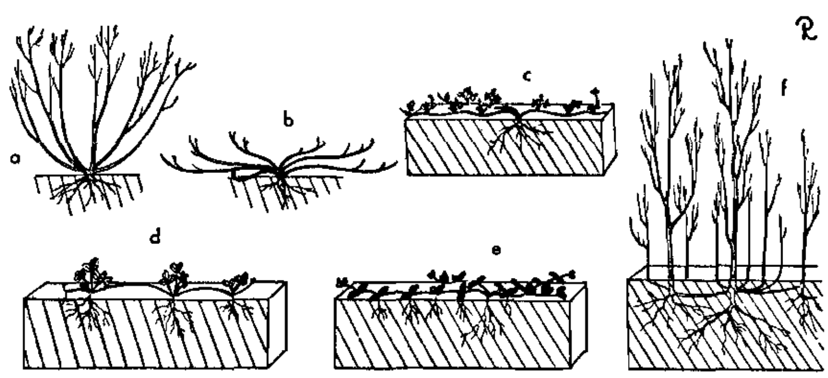

Fig. 10. Stem habit types: a, ascending; b, branches decumbent; c, procumbent; d, stoloniferous; e, repent; f, soboliferous.

such as tendrils, e.g., in the grape or pea; by twisting leaf-stalks, e.g., in clematis; by *cirrhous* leaf tips, such as are present in the Gloriosa-lily; or by production of aerial rootlets, such as in the Poison Ivy or English Ivy.

DURATION AND TEXTURE of stems (and plants) provide such terms as *annual,* meaning living for one year; *biennial* (for stems and plants) living for two seasons, the stem for the first year often acaulescent and rosette-bearing the first season and caulescent the second; *perennial* living several to many seasons (used mostly for plants rather than stems). Plants living two to many years and dying after flowering and fruiting the first time are termed *monocarpic,* such as many bamboos, some palms. *Herbaceous* stems die to the ground after blossoming or at the end of the growing season; *woody* stems live for a successive number of years; *suffrutescent* stems are woody at the base, where they survive from year to year and with herbaceous distal portions (such a plant is *suffruticose*). The *arborescent* habit is that of trees, or of plants that are treelike in appearance, growth, or size.

TYPES OF MODIFIED STEMS, other than described above, are mostly subterranean. The more common of these include *rhizome* (sometimes termed *rootstock,* but a rhizome is properly a stem and not a root), a creeping stem growing beneath the surface, consisting of a series of nodes and internodes with roots often produced from the nodes, and producing buds in the leaf axils (Figs. 11 a, f); *tuber,* a stem (usually but not necessarily underground) much enlarged and modified as a food storage organ with very minute scale-like leaves and buds or "eyes," such as in the Irish potato (Fig. 11 j); *corm,* a very short thick firm fleshy

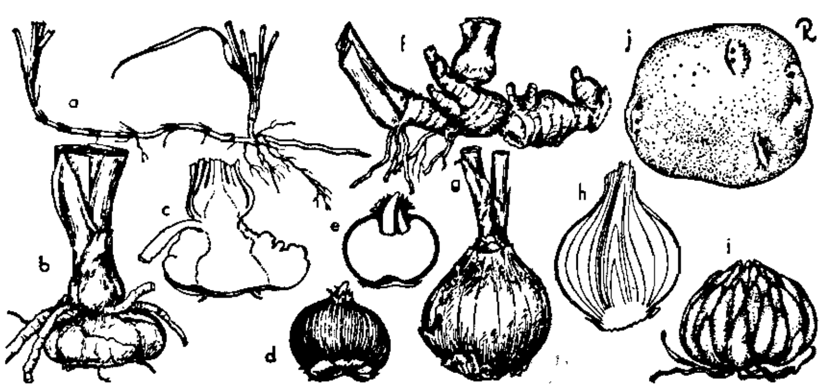

Fig. 11. Underground stem types: a, stoloniferous rhizome; b, corm, with membranous tunic; c, same, vertical section; d, corm with fibrous tunic; e, same, vertical section; f, rhizome; g, bulb, tunicated; h, same, vertical section; i, bulb, scaly; j, tuber.

subterranean stem, usually broader than high, producing stems from the base, and leaves and flowering stems from the top, such as in the jack-in-the pulpit, crocus, and gladiolus (Figs. 11 b, c, d, e); *cormel,* the miniature corm produced annually and vegetatively in leaf axils at the top and upper side of a mature corm; *bulb,* a modified underground stem that is very short, usually flattened, and crowned by a main body composed of usually fleshy, more or less imbricated, non-green, scale-like leaves; bulbs may be covered with a coat or *tunic* which is thin and *membranous* as in onion or tulip (Figs. 11 g, h), fibrous and *reticulated,* or the scales may be naked, e.g., in *Lilium* (Fig. 11 i); *bulbel,* the miniature bulb asexually produced about the base of scales of a mature bulb; *bulbil,* the miniature bulb produced in leaf axils of some bulbous plants or in leaf sinuses; *bulblet,* diminutive for bulb, irrespective of point of origin on the parent plant.

A *cladophyll* is a modified stem resembling a leaf in form and appearance, but arising in the axil of a minute, bractlike, often caducous true leaf, as in asparagus, or *Ruscus*. The so-called leaves of some cacti, as *Opuntia* and the Christmas-cactus, are true stems flattened and superficially leaf-like but are not cladophylls since they do not resemble leaves in form or venation.

BUDS

Buds are much-condensed, undeveloped shoots. Each is a stem with exceedingly short internodes, the leaves and floral parts enveloping one another, and often a bud is covered with leaves modified to scalelike bracts. The buds of woody plants are more conspicuous than those of herbaceous plants and hence are more frequently used for identification purposes. Most buds are mixed. That is, they are nascent ("embryonic") branches bearing both leaves and flowers, but in some plants, such as pear or apple, some buds are flower-producing and others produce only vegetative shoots.

Buds may be in one of several positions—*lateral*, or *axillary*, on the side of the stem (Fig. 12 a); *terminal*, at the stem apex (Fig. 12 g), or

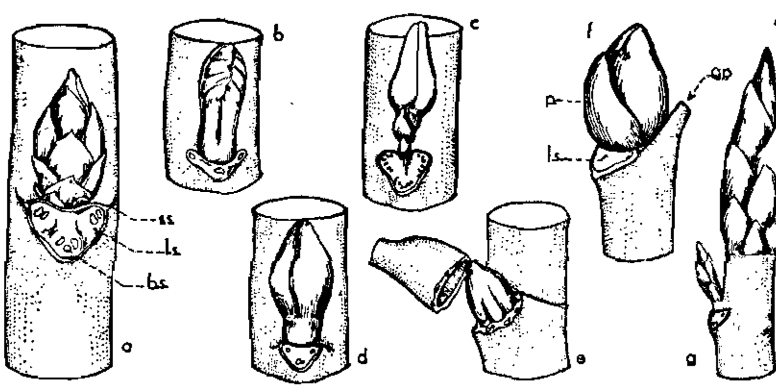

Fig. 12. Bud types and bud-scale arrangements: a, axillary bud with imbricate scales; b, naked bud; c, buds (three) superposed; d, stalked bud with valvate scales; e, subpetiolar bud; f, pseudo-terminal bud; g, terminal bud. (b.s., bundle scar; g.p., growing point abscission scar; l.s., leaf scar; p, pseudo-terminal bud; s.s., stipule scar.)

pseudo-terminal (Fig. 12 f). A pseudo-terminal bud, such as in *Castanea*, the chestnut, is a lateral bud distinguished from a terminal bud by the presence of the abscission scar of a twig that failed to mature (i.e., one that never developed beyond the primordial bud stage) on one side close to the apex and that of the leaf scar on the opposing side of the conspicuous pseudo-terminal bud; the last being a lateral axillary bud that developed so close to the stem apex as to appear to be terminal.

Buds not covered by scales are termed *naked* (Fig. 12 b). Those covered by scales are termed *scaly*. There are two arrangements of bud scales—*imbricate*, with usually several scales whose edges overlap (Fig. 12 a), and *valvate*, with one or few scales whose edges meet but do not overlap (Figs. 12 c, d). Buds may be *stalked*, e.g., in witch-hazel (Fig. 12 d), or more commonly are *sessile*. In some genera, such as the hickories, lateral buds may be *superposed* (Fig. 12 c), and in others, such as sycamore, the buds are *infrapetiolar* and are enveloped by the petiole base of the "subtending" leaf (Fig. 12 e).

LEAVES

Leaves generally provide more characters for identification purposes than all other vegetative parts combined. The terms applied to them are used also to describe parts of the flowers, and sometimes of fruits. The descriptive value of leaves is found in characters of (1) structure, (2) venation, (3) form or general outline, (4) the apex, (5) the base, (6) margin, (7) position and arrangement, (8) vestiture, (9) surface, (10) texture.

STRUCTURE. In its simplest form a leaf consists of a *blade* and its leaf-stalk or *petiole*. When there is no petiole the leaf is *sessile*. There is often a small earlike appendage at each side of the base of a petiole called a *stipule*. A leaf with one blade is generally a *simple leaf* (Figs. 13 b, c). A leaf of two or more apparent blades is a *compound leaf* and each apparent blade is a *leaflet* (Figs. 13 d, e, h, i, j). The stalk of a leaflet, when present, is a *petiolule* (pronounced petty-o-lool), and the tiny earlike appendage sometimes present on each side of the petiolule is a *stiple*.

A *compound leaf* has a petiole and two or more leaflets. When these leaflets all originate from an apparent common point at the end of the petiole the leaf is *palmately compound* (Fig. 13 h). The leaflets may be sessile, as in clover (Fig. 13 i) or each may be borne on a *petiolule* (Fig. 13 h). When the leaflets are borne on a rachis, an apparent continuation of the petiole, the leaf is *pinnately compound*. If such a leaf is terminated by a leaflet it is described as *odd-pinnate* (Fig. 13 d), and when not so it is *even-pinnate* (Fig. 13 e). A leaf that is twice pinnate (also termed *bipinnate* or *two-pinnate*) is *decompound* (Fig. 13 f) and if the decompounding is always in threes, the leaf is said to be *ternately decompound* (such a leaf is also palmately decompound).

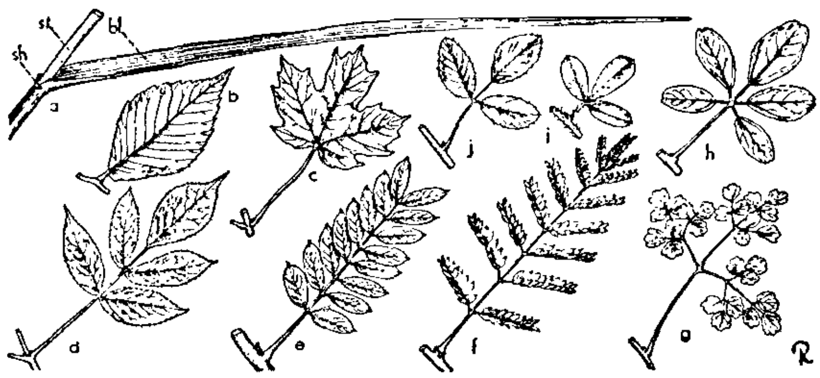

Fig. 13. Leaf parts and types: a, leaf sessile, parallel venation (bl, blade; sh, sheath; st, stem); b, leaf alternate and petioled, pinnate venation; c, leaves opposite and petioled, palmate venation; d, leaf compound, odd-pinnate; e, leaf compound, even-pinnate; f, leaf decompound (2-pinnate); g, leaf decompound, ternate; h, leaf compound, palmate; i, leaf trifoliolate and palmate; j, leaf trifoliolate and pinnate.

A leaf of three leaflets is *trifoliolate* (pronounced try-fo-lié-o-late), a term not to be confused with *trifoliate,* for the latter means three-leaved (descriptive of the situation in *Trillium*). A trifoliolate leaf may be pinnately or palmately compound, depending in part on its origin, for most trifoliolate leaves represent reductions from multi-foliolate ancestral types. If an odd-pinnate five-leaflet leaf has lost the two lowest leaflets it becomes trifoliolate and the terminal leaflet will be stalked. This petiolule of the terminal leaflet (which is composed in part of the rachis top) is longer than those of the lateral leaflets and serves to identify the leaf as pinnately compound (Fig. 13 j). When the terminal leaflet of a trifoliolate leaf is sessile, the leaf is assumed to be palmately compound (Fig. 13 i).

VENATION. Leaf venation is a pattern in the leaf blade representing the major vascular strands. The so-called mid-rib of a leaf is the main strand extending from the petiole to the leaf apex. In much of the literature the veins are called nerves and, while one term is as correct as the other, these vascular strands are in no sense homologues of veins or nerves of animals. There are three basic venation types: parallel, palmate, and pinnate. Combinations of these types also occur.

Parallel venation is that in which the veins are more or less parallel to the leaf margins. There may or may not be a definite mid-vein. Two forms of parallel venation may be noted: the simple parallel form in which all veins extend from base to apex, such as in grasses and irises (Fig. 13 a); and the penni-parallel form in which the veins are parallel but arise from a mid-vein such as in banana, calla-lily, or pickerel-weed.

Palmate-venation is a type of reticulate or netted arrangement in which three or more primary veins diverge from the point of petiole attachment (Fig. 13 c); the pattern formed is often similar to toes of a bird and is sometimes designated *digitate-venation* or *pedate venation.*

Pinnate-venation is the most common reticulate or netted type, sometimes termed *penni-veined,* and is distinguished by the presence of one central mid-vein and many secondary veins arranged along the mid-vein, like the plume of a feather on each side of the shaft.

FORM. The terms given to leaf form or leaf outline, as described in botanical and more general accounts, reflect man's effort to give precision where exactness and conformance to definition may not exist. For centuries botanists have assigned geometrical terms such as oblong, elliptic, or rhombic to forms of leaves. Some leaf forms are equivalents of these terms, others approach equivalency and more represent intermediates between them. However, no more convenient system of leaf-form classification has been devised and botanists continue to use these terms, and hyphenated combinations of them, to express situations. These terms are used also to describe forms of floral parts.

Subulate. Awl-shaped, as a juvenile leaf of Juniper, tapering from base to apex and usually sharp-pointed (Fig. 14 a).

Acicular. Needle-shaped, as a pine leaf, very slender, usually roundish in cross-section and not flattened (Fig. 14 b).

Filiform. Threadlike, often flexuous, very slender and cylindrical, as the divisions or segments of a leaf of fennel (Fig. 14 c).

Linear. Long and narrow, flattened, the sides parallel or nearly so, as blades of many grasses (Fig. 14 e).

Lorate. Strap-shaped, flattened and flexuous, as in many Amaryllidaceae, the tip obtuse or bluntly acute but not tapering to a point (Fig. 14 f).

Lanceolate. Shaped as the head of a lance, broadened at the base and tapering toward the apex, as some *Eucalyptus* or willows (Fig. 14 g).

Ovate. Egg-shaped, broadest below the middle, usually but not necessarily rounded at each end (Fig. 14 h). Some authors differentiate *oval* from ovate, defining the former as "broadly elliptical with the breadth considerably more than half the length" and with the broadest point at or about the middle. More often, oval and ovate are used interchangeably.

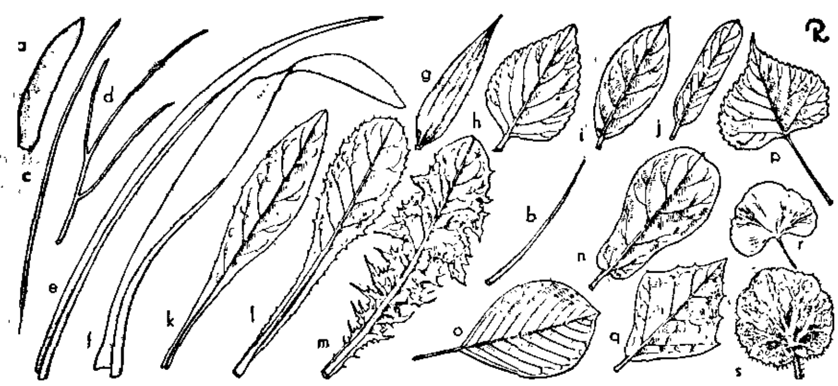

Fig. 14. Leaf form or outline: a, subulate; b, acicular; c, filiform; d, filiform segments; e, linear; f, lorate; g, lanceolate; h, ovate; i, elliptic; j, oblong; k, oblanceolate; l, spatulate; m, runcinate; n, pandurate; o, obovate; p, deltoid; q, rhombate (rhomboid); r, reni-form; s, orbicular.

Elliptical. Similar to ovate but the broadest point midway between the ends and the width about one-half the length (Fig. 14 i). The term may be qualified, when necessary, as narrowly-elliptical or broadly-elliptical, depending on the ratio of width to length.

Oblong. The sides parallel or nearly so, and the length two to three times the breadth (Fig. 14 j).

Oblanceolate. The reverse of lanceolate, with the broadest half above the middle and tapering somewhat toward the base, the apex acute or obtuse or otherwise (Fig. 14 k).

Spatulate. Similar to oblanceolate but tapering to a very narrow base and the apex usually obtuse (Fig. 14 l).

Cuneiform. Wedge-shaped, widest at or near the apex (which is more or less flattened) and tapering to a narrow base.

Runcinate. Generally oblanceolate or spatulate and the sides very coarsely cut or saw-toothed with the teeth pointing toward the base, such as in dandelion (Fig. 14 m).

Obovate. The reverse of ovate, with the broadest half above the middle and the narrower end toward the base (Fig. 14 o).

Pandurate. Fiddle-shaped, a modification of obovate with concave to varying degrees, such as in some *Ficus* (Fig. 14 n).

Deltoid. More or less equilaterally triangular, such as the leaves of some poplars.

Rhomboidal. About as long as wide, broadest at the middle and tapering to base and apex, shaped like a rhomboid (Fig. 14 q).

Reniform. Kidney-shaped, broad as long or broader, the apex broadly obtuse and the base somewhat cordate (Fig. 14 r).

Orbicular. Circular or nearly so, e.g., as in *Nelumbo* or the garden nasturtium (Fig. 14 s).

THE APEX (pl. apices) of an organ is its terminal end, that which is farthest from the point of attachment. Thirteen variations of apex form are distinguished below and the terms are applicable to any appropriate organ of the plant.

Cirrhose (cirrose). Filiform and coiling as a tendril as in the leaf-tip of Gloriosa-lily. It is also used for the tendril-like petioles of some *Clematis* (Fig. 15 a).

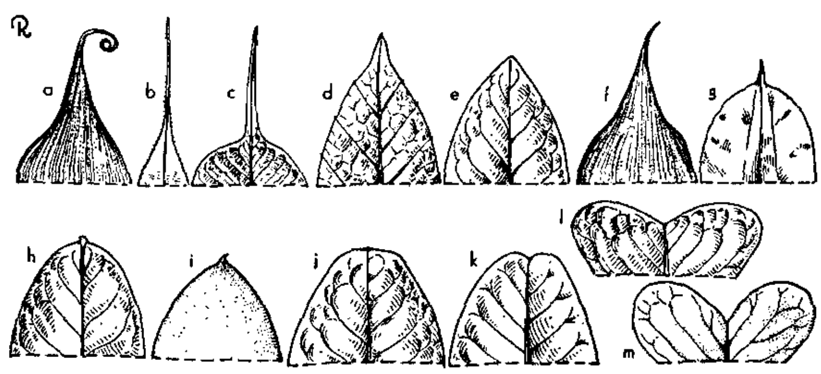

Fig. 15. Leaf apices: a, cirrhose; b, aristate; c, caudate; d, acuminate; e, acute; f, cuspidate; g, mucronate; h, mucronulate; i, apiculate; j, obtuse; k, retuse; l, emarginate; m, obcordate.

Aristate. Terminated by a slender often bristlelike appendage, usually the continuation of the mid-vein, as in oats (Fig. 15 b).

Caudate. Tailed or bearing a tail-like appendage, as in some aroids (Fig. 15 c).

Acuminate. Sharp-pointed, tapering gradually or abruptly with the sides of the apex somewhat concave (Fig. 15 d).

Acute. Sharp-pointed, tapering to a point, the sides straight or somewhat convex (Fig. 15 e).

Cuspidate. Somewhat abruptly and sharply concave and constricted into an elongated sharp-pointed tip, this tip usually rigid (Fig. 15 f).

Mucronate. Abruptly tipped with a shoot projection of the mid-vein (a *mucro*), accompanied or not by a small amount of leaf tissue (Fig. 15 g).

Apiculate. Tipped with a small sharp point not representing an obvious extension of the mid-vein or mucro, but harsh or sharp to touch (Fig. 15 i).

Obtuse. With a rounded apex (Figs. 15 j, 17 h).

Retuse. With a rounded apex very slightly notched at the terminus of the mid-vein (Fig. 15 k).

Emarginate. A condition more extreme than retuse but less so than obcordate, the apex markedly notched but not lobed (Fig. 15 l).

Obcordate. With the apex two-lobed, inversely heart-shaped, such as the leaflet of Oxalis or of most clovers (Fig. 15 m).

THE BASE of an organ is usually the end of attachment. Twelve variations of base types are distinguished below and while all apply to leaf bases, many are equally applicable to other organs.

Attenuate. With the lower sides constricting concavely and gradually into a somewhat winglike petiole, the base "drawn out" (Fig. 16 a).

Cuneate. With a narrow to broad wedgelike taper, acute, the sides straight (Figs. 16 b, 17 a, h).

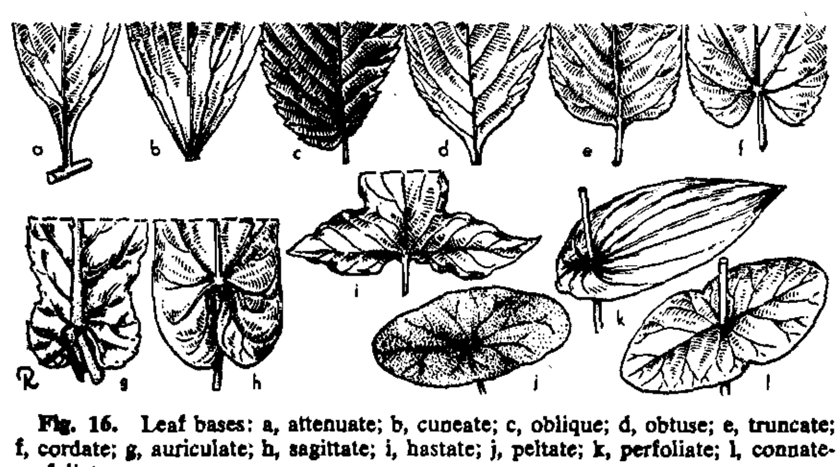

Fig. 16. Leaf bases: a, attenuate; b, cuneate; c, oblique; d, obtuse; e, truncate; f, cordate; g, auriculate; h, sagittate; i, hastate; j, peltate; k, perfoliate; l, connate-perfoliate.

Oblique. With the lowermost sides markedly unequal, such as in *Ulmus* or *Celtis* (Figs. 16 c, 17 f).

Obtuse. Rounded, constricting abruptly to the petiole (Figs. 16 d, 17 e).

Truncate. With a nearly straight line across the bottom, as if cut across (Fig. 16 e).

Cordate. With two lobes giving a heart-shaped appearance, such as in most leaves of common lilac (Fig. 16 f).

Auriculate. With a small earlike lobe (auricle) on either side of the petiole and the two auricles separated by a narrow sinus (Fig. 16 g); sometimes applied to stipules when enlarged and earlike, such as in some *Salix.*

Sagittate. With a pair of basal lobes (or ears) turned downwards and inwards, their apices acute or obtuse, arrow-shaped (Fig. 16 h).

Hastate. With a pair of basal lobes flaring outward (Fig. 16 i).

Peltate. With the petiole attached at or near the center of the lower surface of a usually orbicular blade, such as in Nelumbo or garden nasturtium (Fig. 16 j); a *falsely peltate* situation may occur, such as in Nymphaea or Nuphar, where a cut or sinus extends from one edge of an orbicular or elliptical blade to the center where the petiole is attached.

Perfoliate. With a base that extends around the stem (the leaf being sessile), such as in *Uvularia* (Fig. 16 k).

Connate-perfoliate. With two opposite sessile leaves having their bases fused (connate), such as in terminal leaves of some Lonicera species (Fig. 16 l).

THE MARGIN of leaves and other foliar organs varies widely. Many situations will be found to be intermediate between the conditions accounted by the terms given below and a compound hyphenated term is then used. Some of the terms given below are encountered more commonly in margins of petals or bracts than of leaves (as fringed or laciniate).

Entire. Uncut, without indentation from the margin (Fig. 17 a); an entire margin may however be variously wavy in a vertical plane (as undulate) or may be provided with a row of hairs (ciliate).

Undulate. With an edge wavy in a vertical plane (Fig. 17 b); the margin may be weakly or strongly undulate.

Sinuate. With the margin strongly wavy by turning inwards and outwards but too shallow to be lobed.

Crenate. With obtuse or rounded broad teeth that may be directed forward or at right angles to the mid-vein, scalloped (Fig. 17 c).

Serrate. With sharp rather coarse sawlike teeth that point forward (Fig. 17 d).

Serrulate. A margin representing the diminutive of serrate, finely serrate (Fig. 17 e).

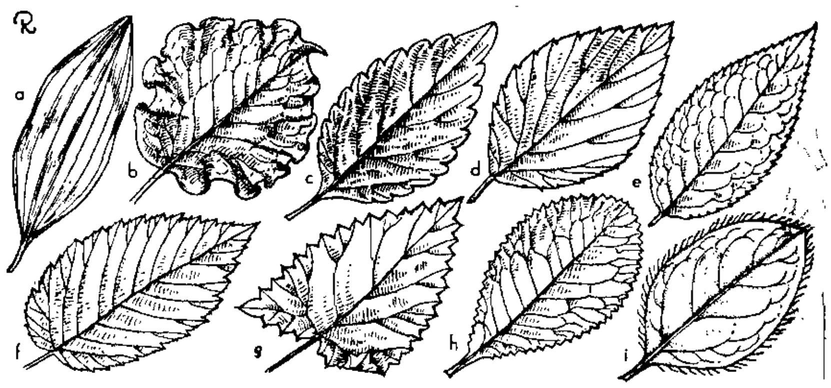

Fig. 17. Leaf margins: a, entire; b, undulate; c, crenate; d, serrate; e, serrulate; f, double-serrate; g, dentate; h, denticulate; i, ciliate.

Double-serrate. With the teeth of serrate margins themselves serrulate or bearing teeth (Fig. 17 f).

Dentate. With sharp rather coarse teeth that point outwards from the mid-vein (Fig. 17 g).

Denticulate. A margin representing the diminutive of dentate, finely dentate (Fig. 17 h).

Ciliate. With a row of fine hairs, sometimes so minute as scarcely to be discernible by the naked eye (Fig. 17 i).

Incised. When the margin is cut jaggedly into very deep teeth (Fig. 18 a).

Lacerate. With the margin irregularly cut about one-half to two-thirds the distance to the mid-vein, the margins of segments so formed may be entire or otherwise (Fig. 18 b).

Laciniate. With the blade cut into narrow more or less ribbon-like segments (Fig. 18 c).

Lobed. With sinuses (incisions) not more than halfway from margin to mid-vein and usually the lobes and sinuses more or less obtuse (Fig. 18 d).

Cleft. With sinuses extending somewhat more than halfway from margin to mid-vein and usually the segment and sinus sharp or acute (Fig. 18 e).

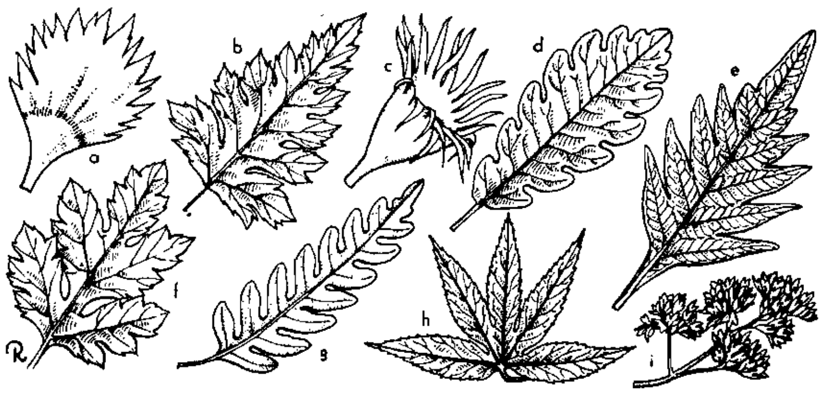

Fig. 18. Leaf margins: a, incised; b, lacerate; c, laciniate; d, lobed; e, cleft; f, parted; g, pinnatifid; h, palmatifid; i, crispate.

Parted. With sinuses nearly but not quite reaching the mid-vein or base of the blade, with the terms two-parted, three-parted, etc., expressing the number of segments produced (Figs. 18 f, a five-parted leaf, 18 g, h).

Pinnatifid. With the margin pinnately cleft or parted (Figs. 18 g, j).

Palmatifid. With the margin palmately cleft or parted (Fig. 18 h).

Crispate. With the margin curled in a vertical plane in minute waves, as in parsley (Fig. 18 i).

Position and arrangement of leaves are sources of fundamental characters, often more constant than most others. Special terms descriptive of the situation include:

Alternate. With one leaf at a node (Fig. 19 a); for critical appraisal of this and kindred terms as applicable to deciduous woody species, it is best to examine the young shoot or twig that is the current season's growth.

Distichous. An alternate arrangement with adjoining leaves on opposite sides of the twig, the third leaf directly above the first in a ½ phyllotaxy (Fig. 19 b).

Opposite. With two leaves at a node, one on the opposite side of the twig from the other (Figs. 19 c, h); in some plants, one leaf of a pair may be slightly below or above the other, a condition called *subopposite.*

Fig. 19. Leaf arrangements: a, alternate; b, alternate, distichous; c, opposite; d, opposite, decussate; e, whorled; f, fascicled; g, imbricated; h, cauline; i, rosulate (basal); j, equitant; k, cross-section through equitant arrangement.

Decussate. A special arrangement of opposite leaves, with the leaves of one pair emerging and disposed at right angles to the pair above and below (Figs. 19 d, g).

Whorled. With three or more leaves at a node (Fig. 19 e).

Fasciculate. With leaves in clusters, often subtended by a bracteate sheath, such as in *Pinus* (Fig. 19 h) where the leaves of each fascicle are borne on a short, very slow-growing shoot and actually are alternate in a high phyllotaxy and with exceedingly short internodes.

Imbricate. With the leaves overlapping, shingle-like, such as in some *Selaginella* (Fig. 19 g).

Cauline. Borne on the stem, as opposed to basal or rosulate (Fig. 19 h).

Rosulate. Borne in a basal rosette, usually but not always on or close to the ground, generally alternate in a high phyllotaxy (Fig. 19 i).

Equitant. Of upward growth, the sides at right angles to the ground and each leaf basally folded together lengthwise and enveloping the next younger leaf, such as in iris (Fig. 19 j with sectional view in 19 k).

VESTITURE

Vestiture (or vesture) implies covering. In botanical writings it refers to the condition of hairiness, scaliness, glandularity, or other covering that may be on the surface of any external part of a plant or organ. When hairiness in general is to be distinguished from other types of vestiture, the term *indumentum* (meaning garment or covering) may be used. Terms of vestiture are commonly applied to stems, leaves, floral components, and fruits. The conditions represented intergrade imperceptibly from one to another and the terms employed cannot be defined within sharp limits, but are used in a relative sense. The distinction between some of these terms is so difficult that botanists of long experience may not diagnose a particular state of vestiture with the same terms, and botanists have been known to use two or more terms for the same situation when faced with identifying it on separate occasions. Because of their relativeness, terms of vestiture and especially of hairiness are difficult to illustrate. In an effort to explain these terms as adequately as possible, they are here described, many are illustrated, and the more common ones then arranged in the form of an analytical dichotomous key.

Terms applied to hairs (*trichomes*) and hairy coverings:

Glabrous. Said of surfaces devoid of vestiture, not properly a term of vestiture but the antonym of those terms.

Glabrate. Essentially glabrous but found, especially by examination with a lens, to be provided with some vestiture, usually very sparsely or minutely so.

Pubescent. A general term lacking any uniformly accepted definition and meaning hairiness of any type, as opposed to glabrous.

Glandular-pubescent. A general term indicating presence of hairs and glands (usually trichome-like glands) intermixed on a given surface.

Puberulous (puberulent). Covered with exceedingly short, fine, rather dense straight hairs at right angles to the surface, scarcely perceptible to the naked eye except when viewed by transmitted light (Fig. 20 a).

Velutinous. Velvety, pilelike, covered with erect straight dense hairs, much longer than puberulous (Fig. 20 b).

Tomentose. Covered with more or less matted woolly hairs, curled and appressed to the surface (Fig. 20 c).

Tomentulose. Diminutive of tomentose.

Floccose. Bearing more or less scattered tufts of appressed woolly or long and soft hairs that rub off easily, such as in some species of begonia.

Arachnose. Bearing a cobweb-like indumentum of long entangled hairs.

Woolly (lanate). Covered with dense, long, soft, entangled, curled hairs, not appressed close to surface (Fig. 20 d).

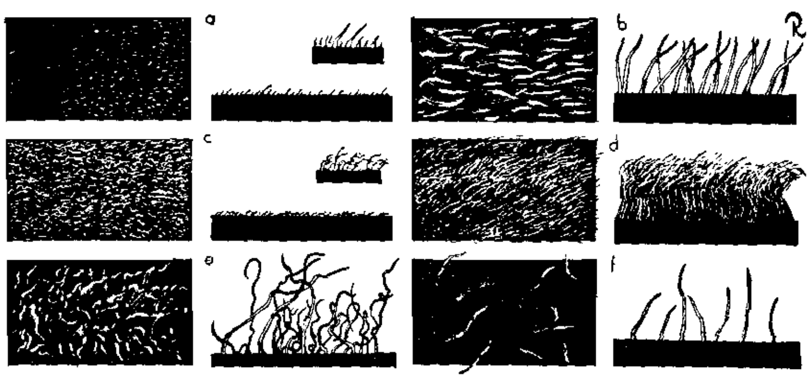

Fig. 20. Vestiture types (surface view at left, sectional view at right): a, puberulous; b, velutinous; c, tomentose; d, woolly; e, villous; f, pilose (a and c with enlarged inserts of sectional view, all others drawn at same scale).

Crisp-hairy. Bearing long kinky hairs, obtusely zigzagged.

Villous. Bearing moderately dense, long, soft, often curly hairs, more or less erect but not necessarily straight (Fig. 20 e).

Pilose. Clothed with soft, very long, rather straight hairs, not dense but somewhat shaggy (Fig. 20 f).

Sericeous. Silky, with straight, soft, long hairs, appressed (Fig. 21 f), often producing a satin-like sheen, especially when dense.

Strigose. With harsh, straight, stiff, short hairs, mostly appressed or weakly ascending, bristle-like in harshness as in some species of *Ulmus* (Fig. 21 b).

Hirsute. Covered with short erect stiff (but not harsh) hairs (Fig. 21 d).

Hirtellous. Minutely hirsute.

Asperous. Rough to the touch, especially when rubbed "the wrong way," a general term without reference to trichome character.

Hispid. Bristly, bearing dense, erect, straight, harshly stiff (but somewhat flexuous) hairs (Fig. 21 c).

Hispidulous. Diminutive of hispid.

Setose (setaceous). Similar to hispid, but not so dense.

Setulose. Minutely setose and probably not different from sparsely or weakly hispidulose.

Scabrous. Covered with scattered harsh hairs, not erect, usually with dilated (or bulbous) bases (Fig. 21 a).

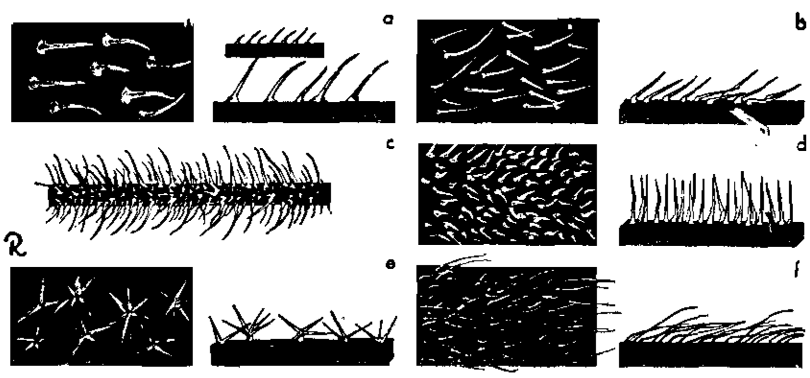

Fig. 21. Vestiture types (surface view at left, sectional view at right): a, scabrous; b, strigose; c, hispid; d, hirsute; e, stellate; f, sericeous.

Scabrescent. Minutely scabrous.

Ciliate. Fringed with a row of hairs (Fig. 17 i).

Plumose. Provided with feather-like compound hairs.

Stellate. Bearing forked or multiple-branched hairs, each on a short central stalk or sessile (Fig. 21 e).

Squamelaeform (squamose). Scaly, provided with flattened usually plate-like sessile hairs (sometimes fringed), or short-stalked and peltate.

Lepidote. Covered with scurfy scales, usually easily removed.

Barbed. Having hairs whose tips are bent back acutely or whose sides provided with teeth or minute retrorse barbs (Fig. 22 h).

Uncinate. Having hairs with obtusely hooked tips (Fig. 22 i).

Clavellate. Club-shaped hairs or glands, broadest at apex (Fig. 22 f).

Echinate. Beset with stiff sharp long spines, as the burr of a chestnut.

Moniliform. A multicellular hair or gland with constrictions between the component cells (Fig. 22 g).

Spiny. Bearing one or more modified stems, leaves or stipules reduced to spines (hard, sharp, needle-like) (Fig. 22 b).

Spinescent. Covered with spines, usually minute ones.

Prickly. Covered with prickles, spinelike excrescences of bark, as in roses (Fig. 22 a).

Aculeate. Furnished with prickles.

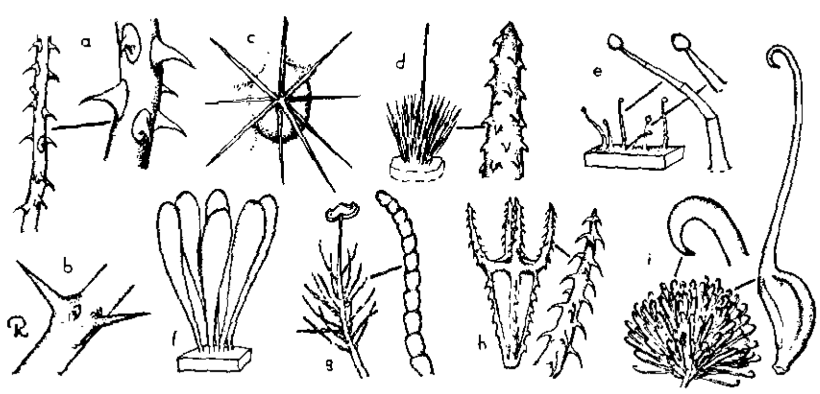

Fig. 22. Armature and special hair types: a, prickles; b, stipular spines; c, areole of spines; d, areole of one spine and many glochids (single glochid shown enlarged at right); e, gland-tipped hairs; f, clavate hairs (or glands); g, stamen bearing moniliform hairs, single hair at right; h, an achene with retrorsely barbed awns, single awn at right; i, uncinate-tipped achenes.

Key to terms of common types of indumentum (adapted from manuscript of Prof. K. M. Wiegand, Cornell Univ.):

1. Hairs compound
    2. Forked, or branched radiatingly .... *stellate*
    2. Pinnate or feather-like .... *plumose*
1. Hairs simple
    3. Surface with some or all hairs knob-tipped (pin-headed)
        4. Trichomes all knob-tipped .... *glandular*
        4. Trichomes mixed, some with knob-tips and others being simple taper-tipped hairs .... *glandular-pubescent*
    3. Surface with none of the hairs tipped by glandular knobs
        5. Hairs curved or bent, at least at tips, not straight
            6. Tips hooked or bent
                7. The tip hooked over obtusely .... *uncinate*
                7. The tip, or teeth at tip, bent back acutely .... *barbed*
            6. Tips straight
                8. Each hair kinky, obtusely zigzagged .... *crisp-hairy*
                8. Each hair curved or bent, not kinky

9. Indumentum close and dense, but not appressed........*woolly*
9. Indumentum close and tightly appressed to surface
10. Hairs distributed evenly, not rubbing off easily ...*tomentose*
10. Hairs scattered in bunches, rubing off easily ......*floccose*
5. Hairs straight
11. Each hair bent at base and pointing toward base of organ bearing same ....*retrorse*
11. Each hair not bent basally, or if so pointing forward
12. Hairs appressed against surface
13. The hairs very short, in bunches, rubbing off ....*floccose*
13. The hairs not in bunches nor rubbing off easily; usually more than 1 mm. long
14. Each hair very short, harsh, stiff ....*strigose*
14. Each hair long, the indumentum usually dense and soft, silky-appearing ....*sericeous*
12. Hairs erect or nearly so
15. The hairs standing out from margin in a row, like eyelashes ....*ciliate*
15. The hairs borne over the surface of the organ
16. Hairs soft to touch, at least not harsh
17. Trichomes 0.5 mm. long, very minute and rather dense ....*puberulent*
17. Trichomes mostly 2 mm. long or more, dense or scattered
18. Hairs medium stiff ....*hirsute*
18. Hairs soft, not stiff
19. Trichomes very long ....*pilose*
19. Trichomes moderately long, very soft
20. Hairs very dense, pilelike ....*velutinous*
20. Hairs not dense nor pilelike ....*villous*
16. Hairs harsh and very stiff
21. The hairs minute, less than 0.5 mm. long ....*hispidulous*
21. The hairs 1 mm. long or longer
22. Trichomes quite dense ....*hispid*
22. Trichomes scattered ....*setose*

SURFACE

Surfaces of major plant parts, as stems, leaves, flowers and fruits, whether devoid of vestiture or not, provide many characters for identification purposes. Some of the more common terms associated with surface types are:

Glabrous. Devoid of all vestiture.

Reticulate. Bearing a net-like pattern represented by weak grooves or color variegation outlining the veinlets beneath; or slight wrinkling, as of a seed-coat, to produce a weakly netted effect.

Rugose. With the reticulation more deeply grooved over the network of veinlets, as in *Rosa rugosa* (Fig. 23 e).

Bullate. A surface appearing as if much puckered or blistered, as in Savoy cabbage (Fig. 23 d).

Papillate. Bearing minute nipple-like projections (Fig. 23 a).

Muricate. Roughened by minute firm epidermal proliferations scarcely classifiable as hairs, squamellose or other types of vestiture (Fig. 23 b).

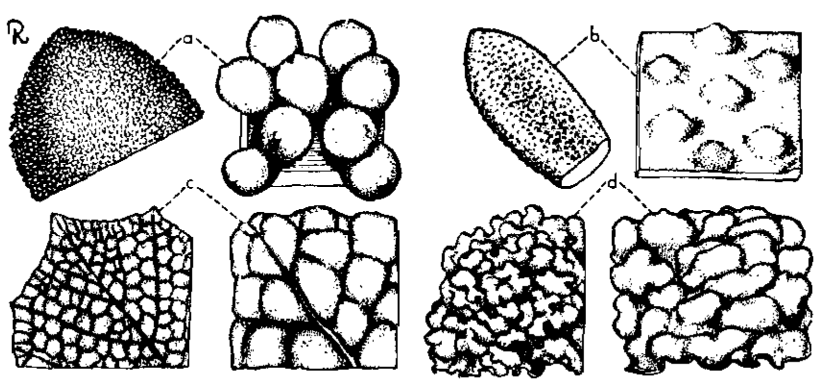

Fig. 23. Surface types (each with highly magnified insert): a, papillate; b, muricate; c, rugose; d, bullate.

Foveolate. Pitted with shallow distinct depressions.

Alveolate. Honey-combed or resembling such by its geometrical uniformity.

Punctate. Covered by minute impressions, scarcely possessing depth, and appearing as if made by a pinpoint, such as seed coats of *Anagallis* or of *Geranium pratense*.

Glandular-punctate. The epidermis provided with minute glands, translucent when pale or amber-colored (as viewed by transmitted light) or blackish, such as in leaves of *Hypericum*.

Striate (lineate). Marked (often by color differences) by longitudinal lines.

Sulcate. Furrowed with longitudinal grooves, such as stems of many members of Umbelliferae.

Annulate. Ringed by circumferential grooves or ridges.

Areolate. Divided into a number of irregular, squarish, or angular spaces.

Fenestrate. Perforated by obtuse window-like openings.

Viscid. Covered with a sticky exudate.

Mucous. Covered with a slimy exudate.

Roridulate. Covered with transparent parenchymatous tissue as elevations or over fenestrations.

Pruinose. Frosted, having an opaque dewy appearance.

Glaucous. Covered with very fine bloom of wax, as on grapes.

Pulverulent. Covered with a very fine powder, representing a waxy exudate.

Farinose. As in pulverulent, but the powder granules coarser.

Glauscent (caesious). Weakly glaucous.

TEXTURE

In addition to such common conditions of texture as herbaceous and woody, there are a score or more of other types, of which the common includes: *hyaline,* thin and almost wholly transparent; *membranous,* thin and semi-transparent; *chartaceous* or papery, opaque but thin; *coriaceous,* leathery and thickish; *cartilaginous,* hard, tough, and often thin; *scarious,* thin and dry, appearing as if shrivelled, such as the phyllaries (involucral bracts) of many species of Centaurea; *suberous,* corky; other terms of texture of equivalent meaning as in English include: *spongy, horny, bony, fleshy, succulent, waxy, fibrous,* and *pithy.*

DURATION

In addition to such terms of duration as annual, biennial, and perennial which concern longevity of plants as a whole, there are others used for various parts of a plant, including: *diurnal,* opening during the day; *nocturnal,* opening at night; *ephemeral,* open for only a day and then perishing; *deciduous,* falling off after maturity (as leaves that fall in autumn); *caducous,* falling off early, as sepals of Papaver; *marcescent,* withering or fading but not falling off; *fugacious,* perishing rapidly and falling: *monocarpic,* bearing fruit but once and dying after fruiting; and *polycarpic,* bearing fruit many times; *protantherous,* when the leaves appear before the flowers; *synantherous,* when flowers and leaves appear at the same time; and *hysteranthous* when leaves appear after the flowers.

THE INFLORESCENCE

An *inflorescence* is now generally accepted to be the arrangement of flowers on the floral axis and is a branch system, but by early botanists it was considered to be the mode of flowering. Present systems of inflorescence classification are descriptive and have little bearing on phyletic origins (for discussion of latter, cf. Lawrence, *Taxonomy of Vascular Plants,* 1951, pp. 59–64). In much taxonomic literature inflorescences are classified as *determinate,* the terminal or central flower developing first and thereby arresting growth by elongation of the primary axis, or *indeterminate,* with the terminal or central flower opening last and the inflorescence often elongating as the flowers develop from lower to upper portions of the primary axis. It is now recognized that the division into these two types is of little significance, since for example the umbel of an onion (*Allium*) is determinate whereas the umbel of the carrot is indeterminate. The sequence of inflorescence types given below is descriptive and arbitrary and makes no pretense to reflect or suggest phyletic relationships.

When the flowers appear singly in the axils of ordinary foliage leaves they are said to be *axillary* and *solitary,* and no conventional inflorescence type is present. However, when the foliage leaves are much reduced in size (or are of different form or character) they are designated *bracts* and the mode of flowering is then an inflorescence of one of the types given below. If the bracts are very small, as compared to the size of the flower, they may be termed *bracteoles.*

The stalk supporting a single flower is a *pedicel.* If the flower has no pedicel it is termed *sessile.* A common leafless axis bearing several flowers (sessile or pedicellate) is sometimes called a *peduncle* and that term may be used also for single flowered "inflorescences" believed to represent a phyletic reduction from a multiflowered ancestral condition (such as in uniflowered species of *Narcissus*). The peduncle in this last type is better known as a *scape.*

A *dichasium,* in its simplest form, is a determinate cluster of three flowers arising from a common peduncle by a dichotomous branching immediately beneath a terminal flower (Fig. 24 q); more common is the *compound dichasium* (Fig. 24 a) such as found in *Gypsophila* or some *Anemone* spp. (Fig. 25 b).

A *cyme* is a determinate inflorescence representing a reduction from a compound dichasium by loss of secondary axes to produce a more or less flat-topped or convex cluster (Fig. 24 m), such as in *Cornus alternifolia* or *Viburnum* spp. A modification of the cyme, and represented by a loss of flowers from the same side of each dichotomy (forking) is the *helicoid cyme* (often incorrectly referred to as a scorpioid cyme) and common among many members of the Boraginaceae, such as Heliotrope,

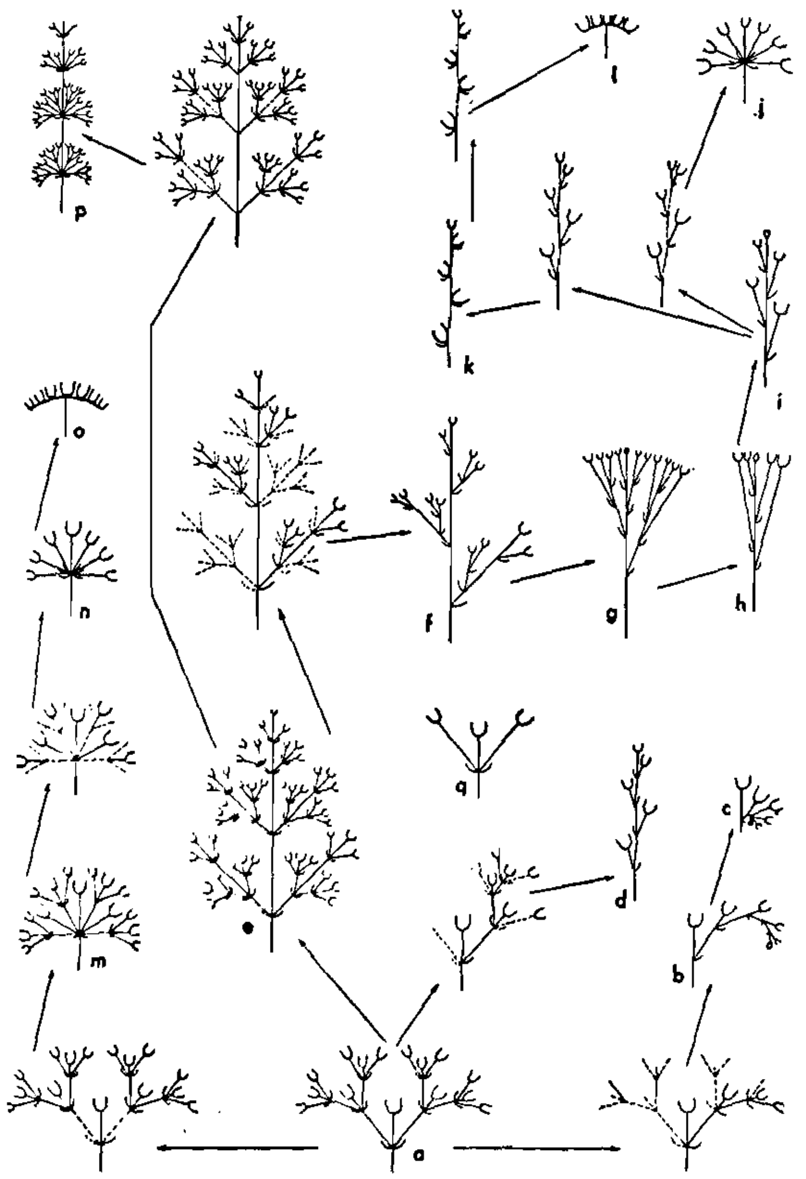

Fig. 24. Schematic diagrams of hypothetical evolution of inflorescence types: a, compound dichasium; b, helicoid cyme; c, cincinnus; d, scorpioid cyme; e, thyrse; f, panicle; g, compound corymb; h, simple corymb; i, raceme; j, indeterminate umbel; k, spike; l, indeterminate head; m, cyme; n, determinate umbel; o, determinate head; p, verticillate inflorescence; q, simple dichasium.

Symphytum or Borago (Figs. 24 b, 25 c). The *cincinnus* (sometimes termed *glomerule*) is a modified helicoid cyme in which the peduncles and pedicels are shortened or absent, such as is to be found within the head of *Armeria* (Fig. 24 c). The *scorpioid cyme* (often confused with helicoid cyme) is a nearly straight but determinate inflorescence and resembles a raceme. An example of this is the lily-of-the-valley (Fig. 24 d). In some plants the flowers of the cyme are much congested and said to be *fascicled* (in a bundle) as in Sweet William. In the Labiate the so-called *verticillate* inflorescence is a primary indeterminate axis (sometimes much condensed and capitulate, e.g., in *Monarda*) bearing pairs of cymes or *cymules* (Figs. 24 p, 25 h, and 60 a).

Fig. 25. Inflorescence types (somewhat schematic): a, corymb; b, cymes (dichasia) (*Anemone*); c, helicoid cyme or cincinnus; d, umbel (*Hoya*); e, capitulum (*Trifolium*); f, capitulum, vertical section, to show conical torus (*Rudbeckia*); g, inflorescence of verticillate cymes (*Salvia*); h, "verticel" (*Salvia*).

An *umbel* is a descriptive term applied to inflorescences whose flowers are pedicelled and the pedicels seemingly arising from a common point at the stem or peduncle apex; often subtended by a number of bracts forming an *involucre*. The umbel may be determinate (Fig. 24 n) or indeterminate (Figs. 24 j, 25 d). It may be simple or compound, as in most Umbelliferae (Fig. 56 a), and when compound each peduncle, which is termed a primary ray bears an *umbellet* or miniature umbel (Fig. 62 b) whose flower pedicels are termed *secondary rays* and whose bractlets form an *involucel*.

A *head* or *capitulum* is an inflorescence of sessile or nearly sessile flowers on a very short or flattened axis (when flattened as in the daisy it is termed the *receptacle*) producing a globose to flat-topped cluster (see Figs. 69 a, b). It may be derived from an umbel (by loss of lower pedicels) or from a spike (by compression of the axis and loss of internodes between the flowers (Figs. 24 j, n). The head may be naked as in *Cephalanthus* or clover (Fig. 25 e) or subtended by an involucre of bracts (*phyllaries*) as in the sunflower or aster.

A *thyrse* is a branch system of compound dichasia, arising from a primary axis of indeterminate growth; this type somewhat resembles and is often confused (as in lilac) with a panicle (Figs. 24 e, 26 f).

A *panicle* is an indeterminate branch system whose primary axis bears branched secondary axes and pedicellate flowers (Figs. 24 f, 26 d), such as in many grasses.

A *raceme* is an indeterminate single axis bearing pedicellate flowers (Figs. 24 i, 26 c). Many so-called spikes are properly termed racemes, e.g., in *Gladiolus*.

Fig. 26. Inflorescence types: a, scapose (flower solitary); b, spike; c, raceme; d, panicle; e, dichasium; f, thyrse.

A *spike* is an indeterminate single axis bearing sessile flowers, such as in Plantago (Figs. 24 k, 26 b). Many so-called spikes are not this inflorescence but only superficially resemble it and should then be termed spicate or spike-like; as, for example, the *catkin* or *ament*, a flexuous spike-like assemblage of bracteate dichasia, in the willow, oak or birch; or the *spadix* of members of the Araceae (usually subtended or enveloped by a large leafy bract or *spathe*).

A *corymb* is an indeterminate flat- or convex-topped inflorescence, a modified panicle (Figs. 24 g and h), such as in some goldenrods.

When the flower, or head of flowers, is solitary and borne on a scape (naked pedicel or peduncle) the inflorescence is termed *scapose* (Fig. 26 a), e.g., in *Cyclamen,* dandelion, and most tulips.

THE FLOWER

A flower is homologous with a leafy stem in that it consists typically of an axis (the pedicel and receptacle) and four whorls of leaf-like components, arranged from the bottom upwards and known as the calyx, corolla, androecium (stamens), and gynoecium (pistils or carpels). These floral components are homologues of leaves in that they have a position and origin comparable to leaves. This does not mean necessarily that they are modified foliage leaves or that they have been derived from them—but they and the leaves may have had a common ancestor. Each of these four sets of floral components is often referred to as a *floral whorl,* or either of the outer two may be designated as a *floral envelope,* even though the actual arrangement may be in a spiral or the units reduced or fused into one. Any understanding of the descriptive terms applied to flowers is predicated on a familiarity of the components typical of most flowers.

FLOWER TYPES AND ARRANGEMENT. A *complete flower* is one composed of all four whorls. An *incomplete flower* lacks any one of them. A *perfect flower* is *bisexual* (*hermaphroditic*) and contains both androecium and gynoecium (Fig. 32 c), but need not possess calyx or corolla. An *imperfect flower* lacks the elements of one sex or the other. A *neutral flower* possesses neither an androecium nor gynoecium, and a *nude flower* has one or both sexes but lacks both calyx and corolla. A flower whose reproductive parts consist only of an androecium (one or more stamens) is a *staminate flower* (Fig. 27 a), and one in which they consist only of a gynoecium is a *pistillate flower* (Fig. 27 b). When a plant bears flowers of only one sex (i.e., the flowers are either staminate or pistillate) it is called *dioecious* (*di-* from the Greek for two, *oecious* meaning households, in allusion to two plants required to house both sexes). An example of a dioecious species is the willow. When a plant bears unisexual flowers, but with flowers of both sexes on the same plant (as in maize or in many cucurbits), it is called *monoecious* (one plant to house both sexes) (see Fig. 26 d).

A flower that is radially symmetrical in form is said to be *actino-*

morphic (Fig. 27 e). If it is bilaterally symmetrical, i.e., divisible longitudinally through the center into two equal halves, as are orchid flowers, it is termed *zygomorphic* (Fig. 27 f); but if it is not possible to divide it into two equal halves, as is true of the flower of the canna, it is called *irregular* (Fig. 27 g). In some works, the term zygomorphic is used to

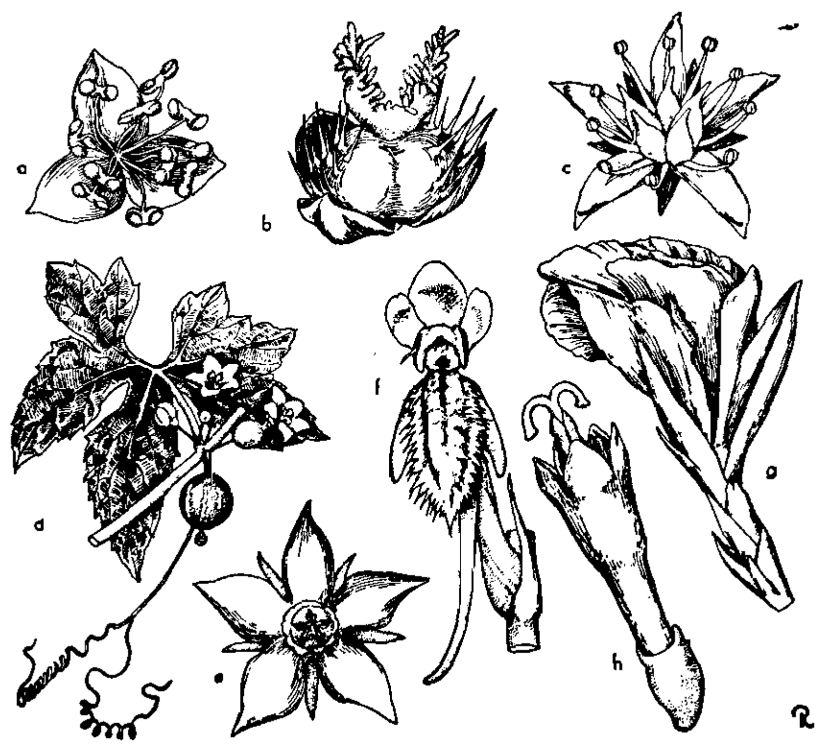

Fig. 27. Flower types and arrangement: a, flower staminate (perianth uniseriate); b, flower pistillate (perianth uniseriate); c, flower bisexual (hermaphroditic) (perianth biseriate and corolla polypetalous); d, flowers unisexual (plant monoecious); e, flower actinomorphic or regular; f, flower zygomorphic; g, flower irregular; h, corolla gamopetalous.

include also irregular. Frequently authors apply one or the other of these terms to flowers, when only perianth or corolla is intended.

PERIANTH is a collective term for the calyx and corolla. When the components of calyx and corolla are similar in size, form, and coloration they are termed *tepals*, e.g., in *Lilium* or *Tulipa*. Terms used to describe parts of the perianth are those used to describe leaves.

Calyx is a descriptive term for the outer whorl of usually green leaf- or bract-like structures called *sepals*. They may be *distinct* [1] and the calyx then said to be *polysepalous* (aposepalous), or *connate* [2] and the calyx then *gamosepalous* (synsepalous), or in some families be reduced to modified hairs or scales and termed a *pappus*. In some genera the sepals are highly colored and the calyx resembles a corolla (such as in *Mirabilis, Delphinium, Helleborus*).

The *corolla* is the second or inner envelope of the perianth and is composed of *petals*. A corolla of distinct petals is termed *polypetalous* (apopetalous), while one in which the petals are connate in any degree (as at the base only or throughout their length) is termed *gamopetalous* (synpetalous). Usually the corolla is colored other than green and contributes to the showiness of the flower.

COROLLA TYPES. The terms actinomorphic, zygomorphic, and irregular, explained above under flower types, are especially pertinent for corolla classification. Polypetalous corollas are commonly actinomorphic and do not vary so much in form as do the gamopetalous corollas. However, among the former there are a few types, as:

Cruciform corollas, such as are found in the members of the mustard family, generally are actinomorphic (zygomorphic in *Iberis*, the candytuft) and consist of four petals disposed in an X or cross-form (Fig. 55 a).

Papilionaceous corollas (the sweet-pea type) are found in the Legume family and are zygomorphic (Figs. 29 e, f, 57 a). There are five petals (Fig. 57 b): a large *standard* or banner which is the most posterior petal, two lateral *wing* petals, and two *keel* petals that are usually connate along the lower edge; this limited extent of connation in no way causes the corolla to be termed gamopetalous, since the petals fall separately and the corolla does not fall as a single piece. A modification is the *cesalpinaceous corolla* in which the standard is in a position anterior to the wings.

There are several types of gamopetalous corollas, whose general outline is also applied to types of polypetalous corollas. The actinomorphic

[1] *Distinct* is used in botanical expressions to indicate complete separation of like parts (as one petal distinct from another), whereas *free* indicates freedom from union of adjoining, but unlike, parts (as the stamens free from the petals).

[2] *Connate* means the fusion of like parts (as petal to petal); *coherent* means the meeting in close proximity by cohesion (by viscidity, vestiture, etc.) or otherwise of like parts but lacking fusion of their tissues (as pollen grains sometimes coherent); *adnate* refers to the fusion of unlike parts (as stamens to petals); *adhesion* refers to the coming into close contact of unlike parts but lacking fusion of their tissues (as the indehiscent husk of *Juglans* adherent to the nut).

types compose one grouping and the zygomorphic another. Those of the former include:

Rotate, (wheel-shaped) with a very short tube and a broad limb at right angles to it, such as in borage or forget-me-not (Fig. 28 e);

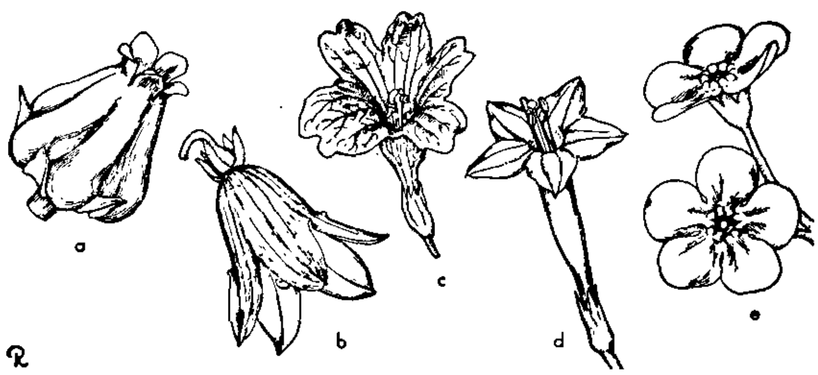

Fig. 28. Corolla types: a, urceolate (*Pieris*); b, campanulate (*Campanula*); c, funnel-form (infundibular) (*Salpiglossis*); d, salverform (*Quamoclit*); e, rotate (*Brunnera*).

Salverform, with a long corolla-type, and a shorter limb that is at right angles to it, such as in tobacco (Fig. 28 d);

Funnelform (infundibular), with a tube gradually expanding upward as does a funnel, the limb may be flaring or somewhat at right angles to the flower axis (the type intergrades with salverform) such as in petunia or morning-glory (Fig. 28 c);

Campanulate (bell-shaped), with a broad tube about as long or longer than broad and a flaring limb or lobes, as in canterbury-bells (Fig. 28 b);

Urceolate, with a large urn-shaped tube, usually somewhat constricted above the middle, and small more or less flaring lobes, such as in *Vaccinium* or *Monotropa* (Fig. 28 a).

Tubular corolla, with a more or less cylindrical tube composing the conspicuous portion; the limb small by comparison, e.g., the disk flower of a daisy (Figs. 27 h, 69 d).

The zygomorphic types include, in addition to the papilionaceous corolla described above, the following:

Bilabiate corolla, in which zygomorphy is due to a two-lipped arrangement of the lobes (in many mints, two lobes form one lip, and three lobes form the other, as shown in Fig. 66 f). The bilabiate type may have the throat open, such as in salvia (Fig. 66 a), in penstemon (Fig. 29 b) or in catalpa, or closed by a *palate* and then termed *personate,* such as in toad-flax (Fig. 29 d) or snapdragon.

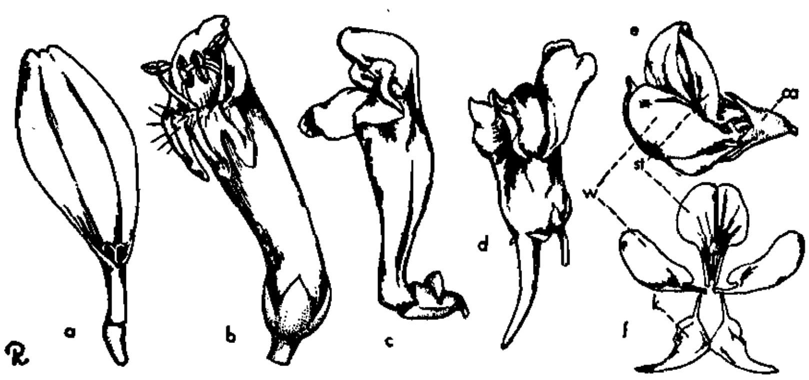

Fig. 29. Corolla types: a, ligulate or ray type (*Helianthus*); b, tubular or disc type (also bilabiate) (*Penstemon*) (see also Fig. 69 d); c, bilabiate, the base geniculate (*Scutellaria*); d, bilabiate and personate, the corolla-base spurred or calcarate (*Linaria*); e, papilionaceous, side view (*Lotus*); f, same, petals spread (k, keel petal; w, wing petal; st, standard or banner).

Ligulate (or ray) corolla characteristic of most of the aster family is a three- to five-lobed gamopetalous zygomorphic corolla that is split along one side and having a large flattened limb and a small tube (Figs. 29 a, 69 c).

Zygomorphy may be due also to a protrusion from the base of the corolla in the form of a *spur*, e.g., in toad-flax or *Linaria* (Fig. 29 d), a large inflation on one side, termed a *gibbosity* (the corolla being *gibbous*), in snapdragon; and when less so the swollen condition is termed *ventricose,* such as on the ventral side of *Scutellaria* (Fig. 29 c).

THE ANDROECIUM is the male reproductive component of the flower and is composed of one or more *stamens*. The stamen is usually composed of an *anther* (the pollen-producing element) and a *filament* (the stalk), but the filament may be so reduced that only the anther is apparent. The stamens may be very numerous, as in Magnoliaceae or Nymphaea, or more commonly are few in number. In some flowers there is only a single stamen (e.g., in *Euphorbia, Typha*). The stamens may be spirally arranged (e.g., Ranunculaceae) or more commonly in two whorls. When in two whorls, those of the outer whorl are generally opposite the petals, a condition called *diplostemony*. When in one whorl, a reduction is believed to have taken place, and usually only those of the outer whorl remain. Sometimes the remnants of the inner whorl are represented by staminodes or nectaries.

Fig. 30. Aestivation and corona types: a, valvate aestivation (*Clematis paniculata*), habit of bud and diagram of perianth arrangements; b, imbricate aestivation (*Tulipa*), habit of flower and diagram; c, convolute aestivation (*Phlox*), habit of opening bud and diagram; d, plicate aestivation (*Nicotiana*), habit of opening bud and diagram; e, corona from perianth, vertical section (*Narcissus*); f, corona from stamen filaments, vertical section (*Hymenocallis*).

The anther is composed of two *anther-sacs* or *thecae*. Sometimes these thecae are called *anther-cells*. The two sacs are separated by a connective, which in reality is the continuation of the filament. Fundamentally each anther is of four thecae (representing four sporangia), but the septum (partition) separating the two on one side of the connective usually disappears during anther development and prior to dehiscence (Fig. 31 Bb), although this is not always true (e.g., in Lauraceae). In the flowers of some families a mature anther is composed of a single theca formed from two sporangia (e.g., Malvaceae) and are sometimes described as one-celled.

When the anther is terminal on the filament (or seemingly so), it is said to be *basifixed* (Fig. 31 Da), and when the filament appears to be affixed to the side of the anther it is *dorsifixed* (Fig. 31 Dc), or sometimes *versatile* (if free-moving on the filament, such as in grasses or lilies [Fig. 31 Db]).

Sometimes, as in Malvaceae, the stamens are connate by their filaments and termed *monadelphous* (Fig. 32 d, e, f). In other families, as in many Legumes, they may be connate in two groups and are then diadelphous (Fig. 57 c). When stamens are connate by their anthers (e.g., in Compositae) they are termed *syngenesious* (Fig. 69 c). In some flowers, as in those of the mint family, the stamens are four in

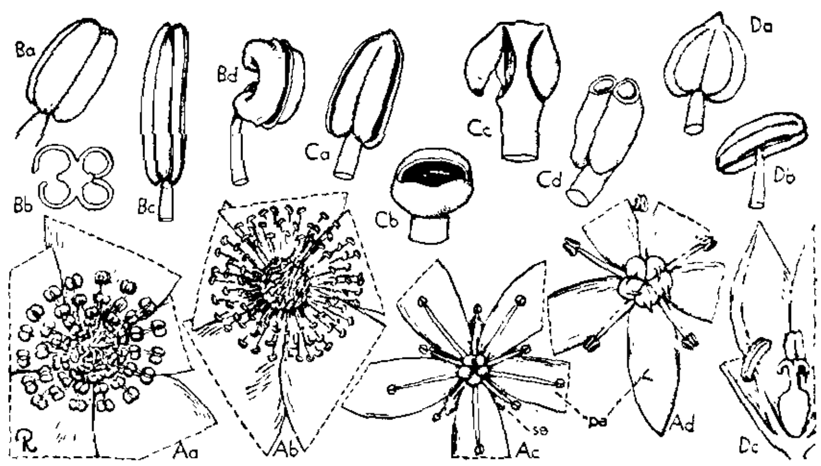

Fig. 31. Androecium and anther types. A, Androecium types: Aa, stamens spirally arranged; Ab, stamens in three whorls; Ac, stamens in two whorls, those of the outer whorl the shorter (diplostemonous); Ad, stamens in a single whorl (dehiscence introrse). B, Anther-cell number: Ba, cells four at anthesis; Bb, same cross-section; Bc, cells two at anthesis; Bd, cell one at anthesis. C, Anther dehiscence types: Ca, longitudinal; Cb, transverse; Cc, valvular flaps; Cd, apical pores. D, anther position: Da, basifixed; Db, dorsifixed and versatile; Dc, dorsifixed, not versatile (dehiscence extrorse).

number and in two pairs, one pair longer than the other, a condition termed *didynamous* (Fig. 32 a); in those of the mustard family the stamens number six, with two shorter than the other four, a condition termed *tetradynamous* (Fig. 32 b).

Stamens provide other characters of taxonomic value. In the aster family they are frequently appendaged. The appendages may be distal at the anther tips, usually by projection and expansion of the connective, or basal and formed by tail-like projections from the anther sacs (Fig. 32 h). In the heath family the filament may be appendaged and be provided with glabrous or variously hairy sac-like swellings (Fig. 32 i). In other taxa stamens may be provided with various types of vestiture, such as moniliform hairs in *Commelina* (Fig. 22 g).

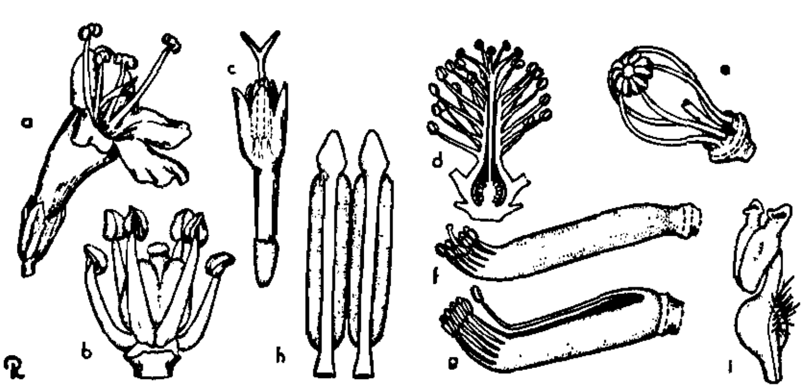

Fig. 32. Androecial types: a, stamens didynamous (*Origanum*); b, stamens tetradynamous (*Thlaspi*); c, stamens syngenesious (*Aster*); d, stamens monodelphous (*Hibiscus*); e, stamens syngenesious (*Sinningia*); f, stamens monadelphous (*Desmosium*); g, stamens diadelphous (*Lathyrus*); h, stamens with apical appendage (*Inula*); i, stamen with basal and ventricose appendage (*Chimaphila*).

Staminodes are sterile nonfunctional and often antherless stamens, present in some flowers as accessory structures. They are not properly a part of the androecium, since they are not a reproductive organ. These are usually the vestigial remains of once-functional stamens. They may be distinct and arise from the receptacle, or be adnate to the corolla. Sometimes they are petaloid in form and color.

Anther dehiscence may be one of several types. When the thecae split along the surface facing outward the dehiscence is termed *extrorse* (Fig. 31 Dc), when along the surface facing an adjoining anther or inward toward the flower axis it is *introrse* (Fig. 31 Ad). In some genera the dehiscence may be *transverse* (Fig. 31 Cb) or at right angles to the vertical axis (e.g., in *Hibiscus, Elatine*); in others it may be by a pore (e.g., in Polygalaceae, most Ericaceae), a dehiscence type that is termed *poricidal* (Fig. 31 Cd). A modification, where the pores are covered by flap-like valves, is found in the Lauraceae.

Pollen grains, produced from most stamens at anther maturity, result from two successive divisions of a *pollen mother* cell within the anther.

The outer membranous coat of a pollen grain is the *exine*. The surface of the exine may be smooth or variously sculptured (furrowed, papillose, honeycombed or areolate, echinate, etc.). Most pollen grains bear three furrows and are termed *tricolpate*; others have a single furrow down one side and are called *monocolpate*. Distinct pollen grains are usually *granular;* those coherent or connate in clusters of four are in *tetrads* (e.g., most Ericaceae); and when the pollen from each theca is agglutinated into a single often hard and horny mass it is termed a *pollinium* (pl., *pollinia*) and is a condition characteristic of most Asclepiadaceae and Orchidaceae (Figs. 49 Bf, 64 d).

Plants pollinated almost exclusively by wind are called *anemophilous*, and those pollinated by insects are termed *entomophilous*. Plants in which the pollen is shed before the maturity of the stigma of the same flower are termed *protandrous* (or proterandrous), and those whose flowers produce mature stigmas before the pollen is shed from stamens of the same flower are termed *proterogynous*.

GYNOECIUM means literally the female household, and in flowers the term is applied to the female reproductive element. The basic unit of the female element of a flower is the *carpel* (Figs. 33 a, b). It is an ovule-bearing structure believed to have been evolved from a non-green leaf-like appendage (homologous with a leaf but not derived from a foliage leaf), and as such was a *megasporophyll*. In ancient flowering plants this megasporophyll is believed to have been palmately three-veined, flat, and to have borne ovules on or near its margins. This prehistoric sporophyll is further believed to have folded lengthwise, with the ovules inside and margins fused. The resultant structure is a unicarpellate, one-loculed *ovary* (Figs. 35 a, 33 c). This ovary is the product of a single carpel and is termed a *simple ovary*. The space within such an ovary (or any ovary) is termed a locule or chamber (Fig. 35 e). In many works it is called a cell, and in them a simple ovary may be described as one-celled. This usage of cell is far removed from the more precise cytological meaning and the terms locule or chamber are preferred.

The upper end of an ovary is terminated by a *stigma* (Fig. 35 d). Pollen grains germinate on the stigma prior to fertilization of the ovules. The stigma may be directly at the ovary apex or, more commonly, it is separated from the ovary by a narrow constricted "neck" termed the *style* (Fig. 35 d). These three structures, ovary, style, and stigma comprise the *pistil* (Fig. 35). The gynoecium may be composed of many distinct pistils (e.g., in the rose, Fig. 39 Ca, or the butte... p, Fig. .. of a single unicarpellate pistil (e.g., in the cherry, Fig. 39 Ba), or, m... commonly, of a single multicarpellate pistil (e.g., in the lily, apple, or cactus).

Placentation is the mode of arrangement of the ovules within an ovary. The *placenta* in the ovary of a flower is not a distinct tissue, as is the placenta in the uterus of a mammal, but is a zone or area occupied by

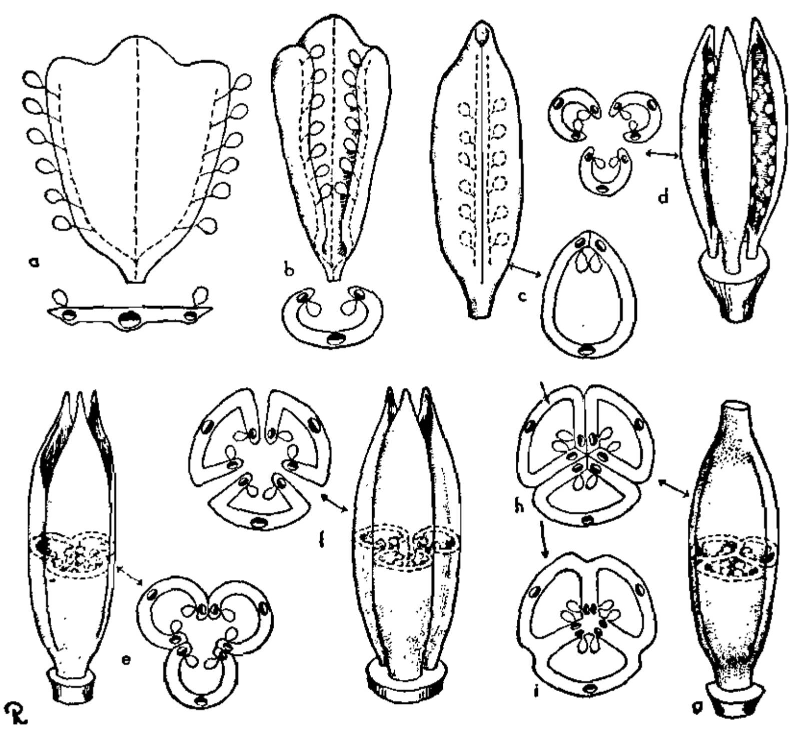

Fig. 33. Hypothetical evolution of simple and compound ovary: a, three-lobed carpel with submarginal ovules (dotted lines indicate vascular strands); b, same, somewhat involute; c, simple ovary derived from "b" by infolding of ovules and connation of ventral margins; d, axis bearing three involute open carpels; e, compound ovary derived from "d" by connation of edges of adjoining carpels; f, axis with three open carpels with adjoining sides more or less parallel; g, compound ovary derived from "f" by connation of adjoining sides and margins; h, cross-section of "g" (hypothetical); i, cross-section of "g" (actual) showing loss of carpellary demarcation in the three septa. (Note: vascular strands shown with xylem elements blackened.)

the ovules. For descriptive purposes, the intrusion of the ovary wall into the locule is often designated the *placenta* (Fig. 35 c, d), and while it usually lacks morphological significance it may provide characters of considerable taxonomic value. In the simple unicarpellate ovary described above the ovules are in a double row along the inner abaxial[3]

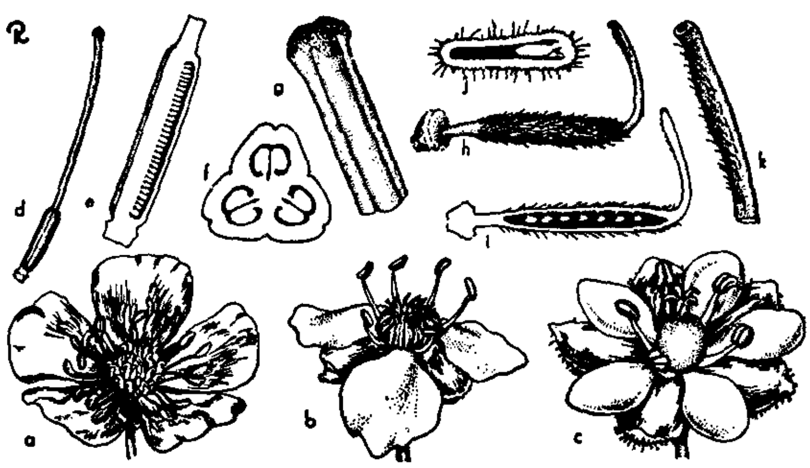

Fig. 34. Gynoecial types: a, pistils many and spiralled, the gynoecium apocarpous; b, pistils many and whorled (cyclic), the gynoecium apocarpous; c, pistil solitary, the gynoecium syncarpous; d, pistil one, ovary compound; e, same, ovary vertical section; f, same, ovary cross-section; g, same, style apex and three-lobed stigma; h, pistil one, ovary simple; i, same, vertical section; j, same, ovary cross-section; k, same, style-tip and simple stigma.

wall of the ovary (Fig. 35 a). The placentation in a simple ovary is termed *marginal* or *ventral*,[4] although sometimes the number of ovules may be reduced to one whose position may be *basal* or *pendulous* from the apex of the locule.

In a majority of unipistillate (apocarpous) gynoecia, a *compound ovary* is present (Fig. 35 b, d). That is, the ovary represents the fusion

[3] The terms *abaxial* and *ventral* are synonymous and mean "toward the axis" or more specifically, toward or on the side nearest the center of the axis. The antonym of each is *adaxial* and *dorsal*, respectively. The ventral side of a leaf (or its abaxial side) is that side facing the axis of the leaf bud before unfolding, the upper side. The axis of an open flower is that imaginary zone that would be occupied by the center of the pedicel if it were projected on through the flower.

[4] In *Taxonomy of Vascular Plants* (p. 75) this type of placentation was termed *parietal*. However, good phyletic reasons have been advanced for restricting the term parietal to a placental situation of the compound ovary.

of two or more carpels. This may have been brought about by any one of several mechanisms and may be represented by different types of placentation. Partially opened ovaries within the same flower standing in close proximity to one another may have become fused. This fusion

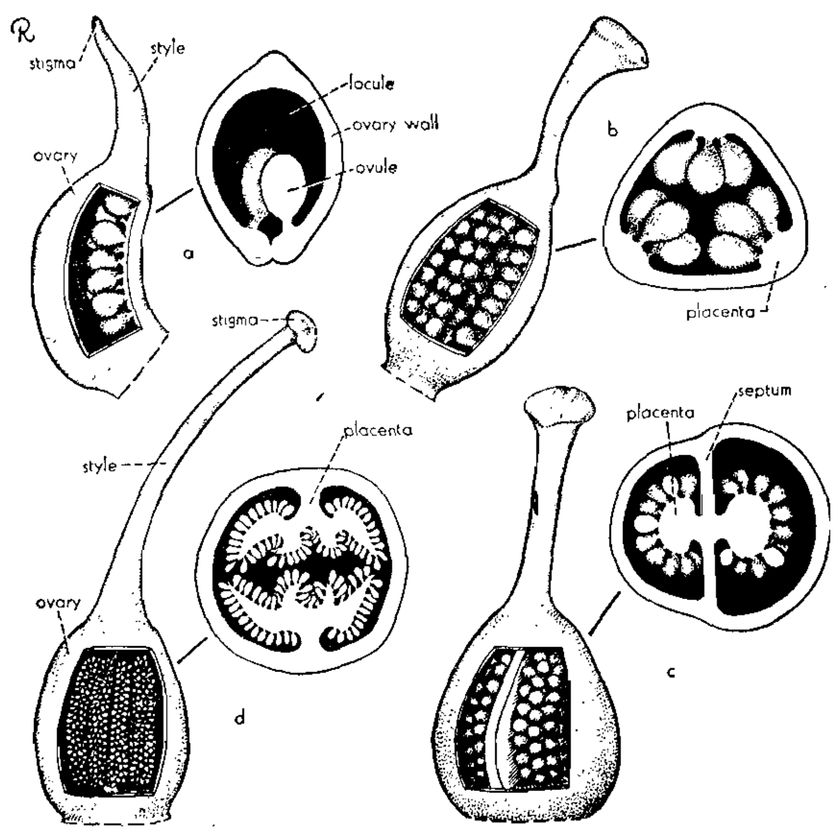

Fig. 35. Placental and carpellary types: a, pistil with simple ovary and marginal placentation (unicarpellate); b, compound ovary with parietal placentation (tricarpellate); c, compound ovary with axile placentation (bicarpellate); d, compound ovary with parietal placentation, each placenta intruded and spreading (bicarpellate).

may have occurred along adjacent ovary margins (Fig. 33 d). It resulted in a single compound ovary that has a single locule and as many placentae as there are carpels (Fig. 33 e). Here the placentae (rows of ovules) are on the inner sides of the ovary wall and the placentation is termed *parietal* (Latin for walls). Usually the number of placentae indicates the number of carpels comprising the pistil (Fig. 35 b). In some situations there may be an intrusion of the ovary wall at the point of union of each adjoining carpel margin. In some extreme conditions the edges within the locule may flare away from one another (Fig. 35 d). These modifications are also considered to be parietal placentation.

When two or more simple pistils (each unicarpellate and unilocular) become fused by their abaxial surfaces, a single compound pistil results.

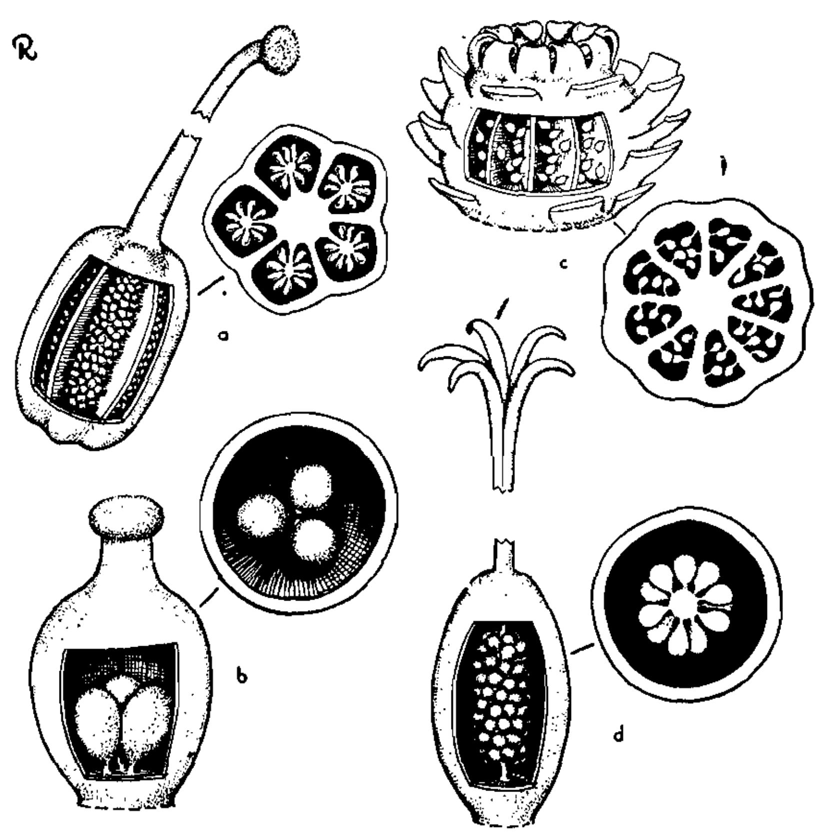

Fig. 36. Placental and carpellary types: a, ovary with axile placentation (5-carpellate); b, ovary with basal placentation (carpel number not determinable); c, ovary with lamellate placentation (9-carpellate); d, ovary with free-central-placentation (5-carpellate)

If two such simple pistils were involved the resultant compound ovary is two-carpellate, two-loculed, and its placental situation is termed *axile* (Fig. 35 c). If five simple pistils were involved the resultant ovary is quinquelocular (Fig. 36 a). The term axile owes its name to the ovules seemingly in the axils of the partitions. The point of common union of these carpels may produce a central axis, but this axis does not represent a continuation of the flower pedicel or receptacle into the ovary.

In the ovary of some kinds of flowers that once had axile placentation, there has occurred a loss of the partitions (the fused walls of two adjoining carpels) leaving a central column bearing as many double rows of ovules as there were original carpels. Such an ovary has a single locule. The placentation in this type is termed *free-central* (Fig. 36 d) and is characteristic of flowers in the primula family and of most members of the pink family (Fig. 53). When, by reduction, the central column and most of its ovules are lost and the few remaining ovules appear to "sit" on the bottom of the ovary locule, the placentation is termed *basal* (Fig. 36 b).

In a few families the compound ovary is composed of many carpels and the partitions have the ovules scattered over their surfaces. This situation occurs in *Nymphaea,* the common water-lily, and the placenta-tion type is termed *lamellate* (Fig. 36 c). In the poppy there may be many incomplete partitions converging from the inner surface of the ovary wall toward the center of the locule (but not meeting there). These intrusions bear an abundance of ovules over their surfaces. This placental type is classed as parietal since all placentae appear to be intrusions of the ovary wall.

Styles and stigmas provide important taxonomic characters. Ordinarily their number is a guide to the carpellary number of the ovary below. Styles may be simple (Fig. 37 b) or branched (Fig. 37 a, d), or sometimes petaloid (Figs. 37 h, i). In the grasses they are often plumose (Fig. 37 a), whereas in the asters they are simple and forked (Fig. 37 f). The stigma may be obvious because of its enlargement, or it may scarcely be differentiable from the style. When enlarged it may be bluntly lobed as in lily (Fig. 46 d) or tomato (Fig. 35 c); linear and papillate as in many mallows (Fig. 37 e), or markedly discoid as in hibiscus (Fig. 37 c). In Iris and related genera the stigma appears as a narrow transverse line across the lower side of the petaloid style-branch (Fig. 37 h). Often the stigma is recognizable by the presence of a glossy viscid exudate present when receptive to pollination.

The *ovule* is the egg-containing organ within the ovary (Fig. 35 a). After fertilization it develops into a seed. Ovules vary in position and attachment. These distinctions, while of considerable taxonomic value, are difficult to recognize in the field, or in the laboratory, except with a magnification of X 60 or higher. Typically the ovule is borne on a stalk or *funiculus* (Fig. 38 Ab), although it may be sessile. The point where the funiculus meets the ovule is termed the *hilum* (the hilum is

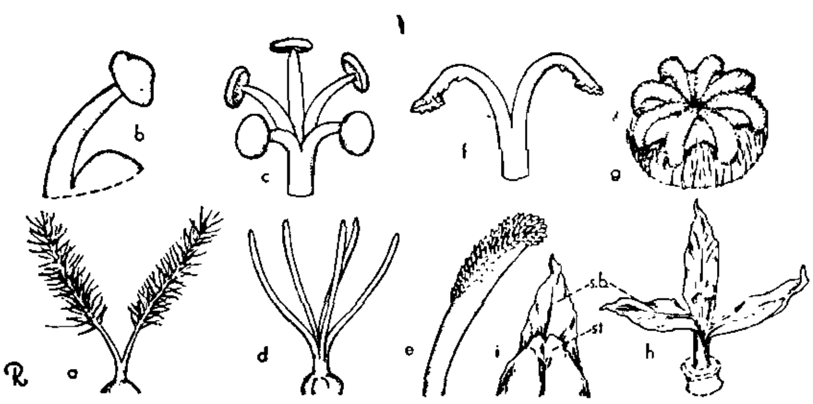

Fig. 37. Style and stigma types: a, stigmas plumose (*Gramineae*); b, stigma capitate (*Alchemilla*); c, stigmas discoid (*Hibiscus*); d, style branches filiform (*Armeria*); e, stigmas linear (*Kitaibelia*); f, style bifurcate (*Arnica*); g, stigma branches radiate (*Papaver*); h, style branches petaloid (*Iris*); i, stigma transverse (*Iris*) (s.b., style branch; st, stigma).

also the scar left when a seed breaks from its "stalk" as in a bean). The opening or "mouth" of the ovule is the *micropyle* (Fig. 38 Ad) or *foramen.* The body of the ovule is the *nucellus* and it is typically enveloped by two coats or *integuments* (Fig. 38 Ad).

Ovule positions of taxonomic importance include:

Orthotropous, a condition present when the ovule stands straight and the micropyle is at the end away from the funiculus, as in buckwheat (Fig. 38 Aa);

Campylotropous (incurved), when the ovule is curved and the micropyle nearly meets the funiculus, as in chickweed (Fig. 38 Ad);

Amphitropous (half-inverted) when the developing ovule retains an essentially straight axis but turns 90° on its funiculus with the latter fused to its exterior for that part of the turn, as in Mallow (Fig. 38 Ab); and

Anatropous (inverted), when an ovule has turned 180° during its development and stands with the funiculus fused along one side and the micropyle close to the placental surface, as in most taxa (Fig. 38 Ac).

Ovary position. The position of an ovary may be superior, inferior, or half-inferior. A *superior* ovary is situated above the zone of attachment of perianth and androecium (Figs. 39 A, B, C), and when th

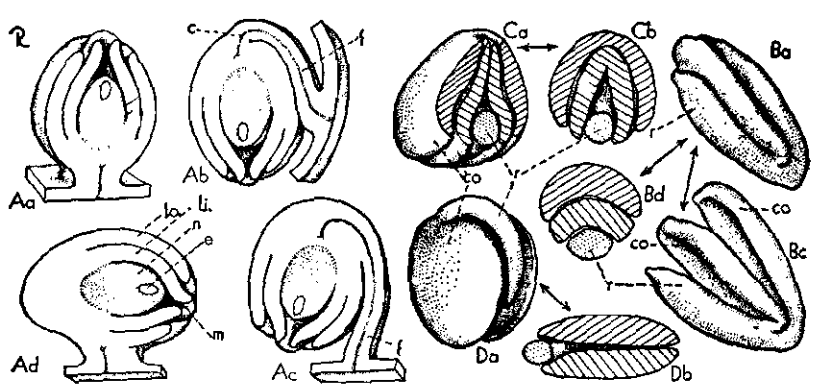

Fig. 38. Ovule and cotyledon types: Aa, ovule orthotropous; Ab, ovule amphitropous; Ac, ovule anatropous; Ad, ovule campylotropous. B, Cotyledons incumbent: Ba, embryo with cotyledons folded against radicle; Bc, same, separated; Bd, same, cross-section. C, Cotyledons conduplicate: Ca, cross-section near distal end of embryo; Cb, same, medium section. D, Cotyledons accumbent: Da, embryo, habit; Db, same, cross-section (c, chalaze; co, cotyledon; e, egg; f, funiculus; Ii, inner integument; Io, outer integument; m, micropyle; n, nucellus; r, radicle).

stamens are adnate to the perianth, it is the area of attachment of the latter that determines the ovary position (i.e., if the ovary is above that point of attachment [superior] or if it is below it). An *inferior* ovary is below the apparent area of attachment of perianth and androecium (Figs. 39 f, g). An ovary whose position is more or less intermediate between the two is termed *half-inferior* or subinferior (Fig. 39 D).

Two theories have been advanced to explain the derivation of the inferior ovary from a superior ovary: the receptacular theory and the appendicular theory. Most older works and some current elementary works explain the inferior position of the ovary solely by the receptacular theory, but a preponderance of anatomical data have brought about a rejection of the validity of this theory for most situations, and the appendicular theory is now the more widely accepted.

The *appendicular theory* of ovary position is predicated on the acceptance of the flower being, morphologically speaking, a determinate

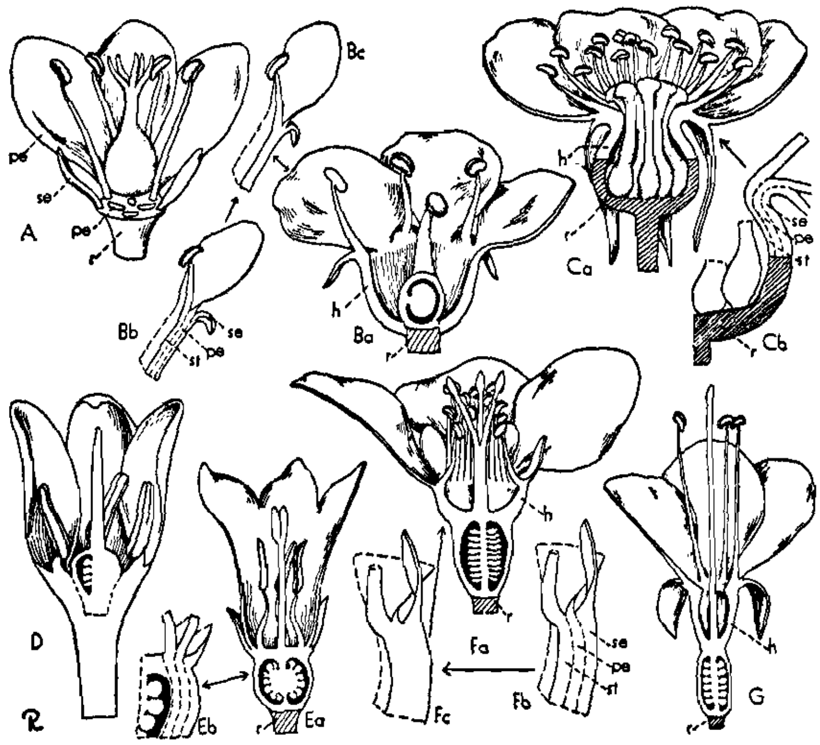

Fig. 39. Ovary position. A, ovary superior, perianth and stamens hypogynous; B, ovary superior, perianth segments and stamens perigynous; Ba, vertical section; Bb, detail of Ba to show composition of hypanthium; Bc, same, minus lines of adnation of perianth and androecium; C, ovary superior, perianth and stamens perigynous, hypanthium of "Rosa" type; Ca, vertical section; Cb, detail to show relation of receptacular cup to hypanthium and composition of latter; D, ovary half-inferior, stamens perigynous; E, ovary inferior, perianth and stamens epigynous; Ea, vertical section of flowers; Eb, detail of same to show adnation of hypanthium to ovary; F, ovary inferior, hypanthium present, perianth and stamens epigynous; Fa, vertical section of flowers; Fb, detail to show components of hypanthium; Fc, section of hypanthium; G, ovary inferior, stamens exserted, hypanthium present. (h, hypanthium; pe, petal; r, receptacle; se, sepal; st, stamen.)

stem with appendages that are homologous with leaves. By this view it is held that some of those appendages were carpellary and contributed to the pistil, that others bore microsporangia and developed into stamens, and that still others below were accessory to the reproductive functions and became the parts of the perianth. In some kinds of plants, as Prunus (the plum), the ovary is surrounded by a cup-like structure on which the sepals, petals, and stamens appear to be borne (Fig. 39 Ba). This structure is termed the *hypanthium* or floral-cup). Anatomical studies show this hypanthium to have been formed by the adnation (fusion) of the sepals, petals, and stamens. The unfused parts of the calyx, corolla, and androecium which appear above the hypanthium are designated as sepals, petals (not calyx-lobes, corolla-lobes), and stamens (Fig. 39 Bb). Inasmuch as the hypanthium is composed of these three elements, it is incorrect to refer to it as a *calyx-tube,* for, strictly speaking, the calyx-tube is the tubular portion of a gamosepalous calyx.

In most plants, the inferior ovary differs morphologically from the superior ovary by the adnation to it of the lower portions of calyx, corolla, and stamens (Figs. 39 Eb, Fb). It represents a stage of phyletic advancement over the more primitive superior ovary. These adnate sepals, petals, and stamens are appendicular (appendage) parts of the flower and do not comprise the distal end of the receptacle or torus.[5]

By the *receptacular theory* it was believed that the inferior ovary was embedded in or surrounded by a tube or cup of receptacular tissue (as if the ovary were pushed into the receptacle), and that the hypanthium of the superior ovary likewise was a tube of receptacular tissue. Although most older works, and some contemporary semi-popular books, present the receptacular theory as the explanation for the inferior ovary, this theory is nowhere accepted by scientists today as representing the situation for the large majority of plants with inferior ovaries.

THE FRUIT

A fruit may be defined as the product of a ripened ovary, pistil, or gynoecium of a flower and may be composed in part of accessory floral or vegetative parts. It is the seed-bearing (or seed-containing organ of a plant). Fruits are important in the classification and identification of seed plants, because generally they provide characters very reliable in the de-

[5] This is the prevailing situation in flowers with an inferior ovary. There is anatomical evidence that in some plants the basal portion of the hypanthium (or of tissues adnate to the ovary) is composed in part of receptacular tissue, e.g., in the hypanthium of Rosa, and the inferior ovary of some members of the Santalaceae (see Fig. 39 Cb).

limitation of genera and of families. Many kinds of fruits exist. Various classifications have been proposed but all in common usage are based on descriptive features of the fruit rather than on their comparative morphology and anatomy. For this reason the classifications now in use, and inherent in taxonomic writings, are artificial and do not reflect basic morphological situations. The types of fruit currently recognized in most of the literature are differentiated grossly in the following synopsis (reproduced from *Taxonomy of Vascular Plants*):

- Fruits simple, the product of a single pistil.
  - Fleshy and usually indehiscent.
    - Texture homogeneous, fleshy throughout … *Berry*
    - Texture heterogeneous.
      - Fruit exterior a firm, hard, or leather rind.
        - Septate present, several to many … *Hesperidium*
        - Septate absent … *Pepo*
      - Fruit exterior soft.
        - Center of fruit with a single "stone" which contains the seed … *Drupe*
        - Center of fruit with paper or cartilaginous carpels … *Pome*
  - Dry fruits.
    - Fruit indehiscent, usually one- to two-seeded.
      - Winged … *Samara*
      - Wingless.
        - Pericarp thin.
          - The pericarp adnate to the seed … *Achene*
          - The pericarp loose and free from seed … *Utricle*
        - Pericarp thick and hard, sometimes bony.
          - Fruit small, from a one-loculed ovary … *Achene*
          - Fruit usually large, from a two- to more-loculed ovary … *Nut*
    - Fruit usually dehiscent, one- to many-seeded.
      - Product of a unicarpellate ovary.
        - Dehiscing by ventral suture only … *Follicle*
        - Dehiscing by two longitudinal or transverse sutures.
          - Sutures longitudinal … *Legume*
          - Sutures transverse … *Loment*
      - Product of a bi- or multicarpellate ovary.
        - Fruit splitting into one-seeded halves … *Schizocarp*
        - Fruit splitting and releasing seeds.
          - Dehiscence circumscissle … *Pyxis*
          - Dehiscence longitudinal … *Capsule*
            - (Silicles and siliques are specialized types of capsules characteristic of the Cruciferae.)
- Fruits compound, the product of two or more pistils.
  - The product of several pistils of a single gynoecium connate or coherent, and usually fleshy … *Aggregate fruit*
    - (An *accessory fruit* is a type of aggregate fruit in which the conspicuous and often fleshy part of the fruit is of nonovarian origin.)
  - The product of several gynoecia aggregated in one mass … *Multiple fruit*

From the above it may be noted that some fruit types more or less parallel family limits. The *hesperidium* is found only in the citrus family, Rutaceae, but is one of several types produced in that family. The *pepo* is characteristic to a large extent of members of the gourd family, Cucurbitaceae. The *pome* (Fig. 41 f) is represented by the fruit of the apple, pear, cotoneaster, etc., in the Rosaceae, and the *legume* (Fig. 40 j) and *loment* are common only to the legume family.

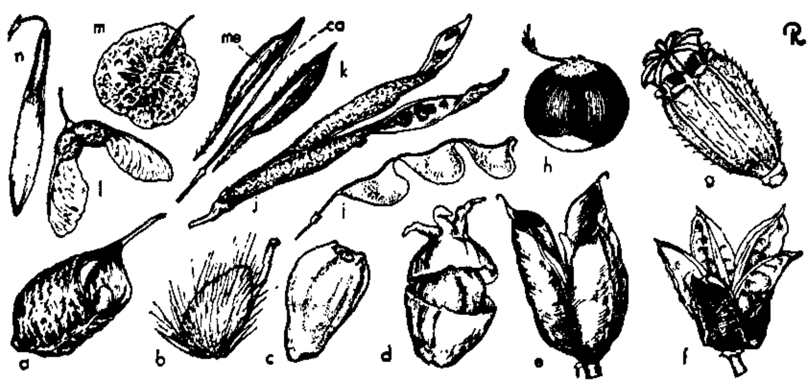

Fig. 40. Fruit types (dry): a, follicle (*Helleborus*); b, achene (*Potentilla*); c, achene (*Compositae*); d, pyxis (circumscissile); e, capsule (septicidal); f, capsule (loculicidal); g, capsule (poricidal); h, nut; i, loment; j, legume; k, schizocarp; l, samara (*Acer*); m, samara (*Ptelea*); n, samara (*Fraxinus*); (ca, carpophore; me, mericarp).

Aggregate fruits occur in several families but are well known by the blackberry-raspberry alliance (*Rubus*) of the Rosaceae (Fig. 41 g), to which family belongs also the strawberry, whose gross fruit is of the *accessory* type but in which the true fruit is an achene embedded in the enlarged fleshy receptacle (Fig. 41 h, k, l).

Multiple fruits are those in which the gynoecia of several flowers form a single structure. These are common to the mulberry family, Moraceae. Here, as in the fig, the conspicuous fleshy part develops from the receptacle. In the mulberry the gynoecia retain their individuality and resemble tiny drupelets aggregated into one mass.

The dehiscence of dry fruits refers to the mode of the splitting or opening of a fruit for release of seeds and provides valuable diagnostic characters. There are several types of dehiscence of dry fruit, of which the follicle, legume, loment, capsule, nut, and schizocarp are examples. A *follicle* is the product of a one-carpelled unilocular ovary (Fig. 40 a) and dehisces by a single suture (line). It may be many-seeded or one-seeded. A *legume* is a product of a unicarpellate ovary, but differs from a follicle in dehiscing by two lines or sutures, as in the common bean (Fig. 40 j). A *loment* has a similar morphological origin but is strongly contracted between the seeds, falling apart (when mature) at the constrictions into one-seeded segments or joints. A *capsule* is the product of a multicarpellate ovary. A *loculicidal* capsule is one in which the line of dehiscence (the split) opens directly through the capsule wall into the locule (Fig. 40 f). A *septicidal* capsule is one in which the line of dehiscence is from the capsule wall at the point where the septum (partition) joins it, and often the septum is split longitudinally (Fig. 40 e). A *poricidal* capsule dehisces by pores. Each pore may be provided by a lid or *operculum* or not. The pores may be at the top of the capsule, as in the poppy (Fig. 40 g) or at the base as in some species of Campanula. A *circumscissile* capsule, known also as a *pyxis,* dehisces by a circumferential line whereby the top comes off as a single piece, as in portulacca (Fig. 40 d). A *nut* is a one-seeded fruit enclosed in an involucre [6] and its diminutive form is *nutlet.* It may be dehiscent or indehiscent. A *schizocarp* is a dry fruit dehiscing into two equal one-seeded halves (each a *mericarp*) and usually suspended or supported from a short central axis (stylopodium) by a wiry *carpophore.* This type of fruit is common to the carrot family and to the samarous fruits of maple. Dry indehiscent fruits include the nut (discussed above) samara, utricle, and achene. The *samara* is a one-seeded winged fruit. The wing may be on one side as in the ash (Fig. 40 n) or may surround the seed and be disciform, as in the wafer-ash (Fig. 40 m). The *utricle* is a one-seeded usually small, bladdery fruit as in Atriplex. An *achene* is a one-seeded indehiscent fruit in which the pericarp (outer layer) is firmly adnate to the seed.

Achenes are the fruit-type encountered in the aster family, and here there are many modifications in form and appearance of taxonomic value. The achene may be attenuated into a beak which, in lettuce and dandelion, is terminated by a whorl of plumes (Fig. 42 a); it may be winged and have terminal awns in the form of bristles, spines (Fig. 42 c), or be terminated by a double pappus (Fig. 42 h, i). The achene surface may be smooth or variously ribbed, glandular, echinate, or papillate.

[6] The involucre is an accessory part of the fruit and may be cup-like and represent the fusion of abundant bracts as in the oak, or bur-like and of similar origin as in the chestnut, or somewhat capsular as in the beech. The acorn of the oak is the nut plus the cup-like involucre and the term is not synonymous with nut, or with the nut of a particular kind of tree.

Fleshy fruits are more difficult to classify but in general are one of basic types. The *berry* is any fleshy fruit containing one or more seeds as the grape, date, and tomato. The *drupe* is a fleshy one-seeded fruit in

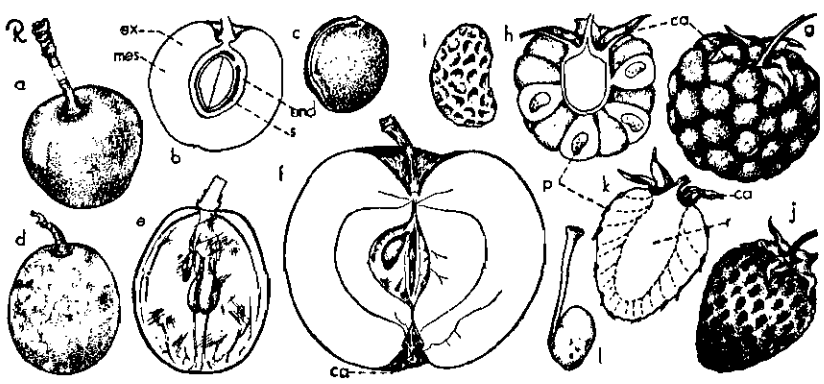

Fig. 41. Fruit types (fleshy): a, drupe (*Prunus*); b, same, vertical section; c, pyrene or "pit" of drupe; d, berry (*Vitis*); e, same, vertical section; f, pome (*Malus*), vertical section; g, aggregate fruit of drupelets (*Rubus*); h, same, vertical section; i, pyrene from *Rubus* drupelet; j, accessory fruit (*Fragaria*); k, same, vertical section; l, achene from *Fragaria* fruit. (ca, calyx; end, endocarp [bony wall of pyrene]; ex, exocarp; mes, mesocarp; p, pyrene [the so-called "pit" or seed]; r, receptacle; s, seed.)

which the seed is enveloped by a stony endocarp (formed from part of the ovary wall). Here, as in the plum, peach, or olive, the exocarp is the "skin," the mesocarp is the pulpy "flesh," and the endocarp, the bony structure enveloping the seed; the bony endocarp plus the seed comprise the "stone" or "pit." Sometimes the "pit" of a drupe or more commonly of a drupelet is termed a *pyrene*, as in the raspberry (Fig. 41 h, i).

Seeds are fertilized mature ovules. Each seed is composed of one or two seed coats, the endosperm (sometimes lacking) and the embryo. The embryo is made up of a plumule, one to two cotyledons (rarely more), a hypocotyle, and radicle. The external features, aside from the seed coat, are: the *hilum*, a scar that marks the place of funiculus (stalk) attachment; the *raphe*, a ridge formed by the funiculus (and produced only by anatropous ovules); and *micropyle*, a minute scar (not always present) indicative of the opening into the ovule. Taxonomically, these features are not used extensively, except for the surface characters of the seed coat and (in the mustard family) the arrangement of the cotyledons and radicle. In some taxa the location and form of the embryo provide important characters for delineation of a genera and family; in others the presence (or absence) and character of endosperm are of equal diagnostic value. However, while these are characters of phyletic significance, they rarely are suited for field use or general identification purposes.

The shape, surface, and "appendages" of seeds often are of value as field characters. Seeds may be *plumose,* as in milkweed (Fig. 42 q), or *winged,* as in the trumpet-vine (Fig. 42 n) or the surfaces variously

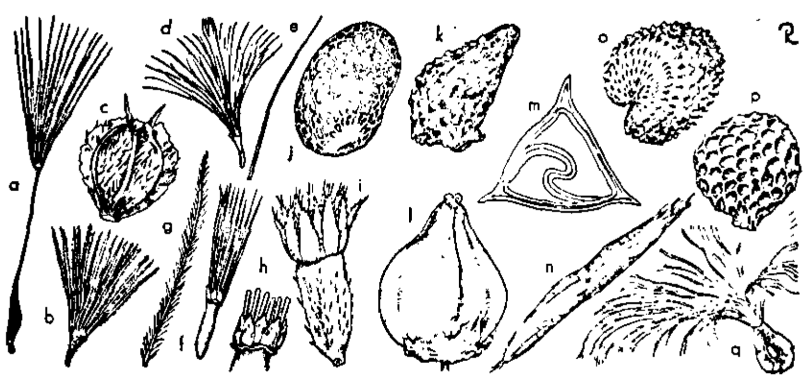

Fig. 42. Achene and seed types: a, achene, beaked (*Tragopogon*); b, achene, plumose pappus; c, achene, winged and awned; d, achene, capillary pappus; e, same, detail of capillary trichome; f, achene with double pappus, of scales and plumose trichomes; g, same, detail of plumose trichome; h, same, detail of outer pappus scales (trichomes excised); i, achene with pappus of scales; j, seed with reticulate coat (testa); k, seed with muricate surface; l, triquetrous smooth seed (*Fagopyrum*); m, same, cross-section, embryo curved; n, seed, winged; o, seed with rows of tubercles; p, seed with alveolate or honeycombed surface, pitted; q, seed winged and with coma.

sculptured or *papillate* (Figs. 42 j, k, o, p). The number of seeds within a locule or fruit often provides reliable distinguishing characters, as may the size, color, and form.

The position of the cotyledons and radicle within the seed may be of taxonomic value, especially in the crucifer family (see Fig. 49). When the two cotyledons have their edges against the radicle they are said to be *accumbent;* when one side of the cotyledon rests on the radicle, they are said to be *incumbent;* and when the two cotyledons fold over the radicle, they are said to be *conduplicate.*

CHAPTER V. *Collecting and Identifying Techniques*

A PART of the training of every taxonomist and professional botanist includes the preparation of herbarium specimens—the pressing, drying, and mounting of plants. This chapter is designed to meet the needs, not of the professional, but of the amateur botanist, the naturalist, and the person whose curiosity has been whetted to the point of wishing to prepare an "unknown" for personal use or to send to an authority for identification and naming. Very often one sees flowers in woods or fields and wishes to preserve material for future identification. It is good to know and practice the right ways of doing this.

For the beginner, it is more simple to sit with some freshly collected flowers and "work out" their identity with a flora or manual than to work over flattened and dried specimens later. Frequently it is easier to study and understand the structures and floral organs from fresh flowers than from pressed ones. With experience, the latter present no difficulties. Aside from the requisite flora or manual—desirably one with keys—it is only necessary to obtain a good hand lens (preferably one with a Hastings triplet lens, or at least a Coddington type lens, of $\times$ 7 or $\times$ 10 magnifying power), a pair of forceps, and a sharp scalpel or razor-blade, plus, of course, flowers to dissect.

The inexperienced person should select, as a "starter," a plant having large flowers, and avoid those such as of the aster family or others equally minute which are more complex than is apparent. It is folly to attempt to identify an unknown in a hurry. Study the plant and especially the flower before attempting to identify it with aid of a book. Observe the nature of the perianth and be able to name its parts. Count the parts.

Note whether sepals and petals are fused or distinct. Note the number of stamens, where they are attached, and the positioning of the anthers. Investigate the gynoecium, count the number of pistils, of styles and stigmas. Slice a flower lengthwise through its center and note the point of attachment of the calyx and corolla and observe the ovary position (whether superior, inferior, half-inferior). Remove the perianth from another flower, and the stamens, too. With a sharp blade, slice crosswise through the ovary, and identify the carpellary and placental situation. Observe the number of locules of the ovary, the approximate number of ovules, and then decide whether the placentation may be marginal, axile, parietal, or free-central. Sometimes the ovule is solitary, or the number is few, and the position basal or pendulous. If these characters are determined from a preliminary study, the process of identification becomes more sure, and one is more confident of step-by-step decisions.

IDENTIFICATION

After the plant has been examined, and familiarity has been gained from study of its flowers, the next steps are to identify and name it. This calls for the use of a book. If available, a simple local flora or guide written for use in the particular region should be sought. This, in preference to the larger, more technically written manuals that cover a major region of the country but which are more difficult for the beginner. Simple works, such as Muenscher's *Keys to Woody Plants*, Jones' *Flora of Illinois*, or Styermark's *Spring Flora of Missouri* (and there are many others for other areas), are to be commended to the beginner. Spring flowers are well suited to "first tries" and come at a season when field collecting is most inviting.

A key, for plant identification purposes, is a device whereby combinations of characters not present in the unknown plant at hand are eliminated and by means of those characters that are present, one "comes out" to a final answer. The keys in most modern works are called *dichotomous keys*. In these, contrasting conditions are combined in paired *couplets*, with each of the two opposing situations in the couplet termed a lead. The following is an example:

1. Flowers short-pedicelled, in racemes; perianth showy.
    2. Ovary superior, stamens six .... *Liliaceae*
    2. Ovary inferior, stamens three .... *Iridaceae*
1. Flowers sessile, in spikes; perianth inconspicuous, or none.
    3. Plants herbaceous; inflorescence with one herbaceous spathe .. *Araceae*
    3. Plants woody; inflorescence with one to many woody spathes ... *Palmae*

The first couplet is composed of the two leads preceded by the figure one. Some authors prefer to designate couplets with letters, using here for example A in place of the first figure one and AA in place of the second. In the key above there is a total of three couplets. Note that the leads of any one couplet provide opposing statements. One is supposed to fit the situation, and the other does not. If, for example, the situation in the second lead of the first couplet prevails, then determine if it is the first or second lead of the third couplet that matches the condition in the unknown. Ultimately, one arrives at a name of the family, genus, or species of the plant under study.

Often a book will contain one key by which to identify the plant with its family, and a second key (or series of keys) by which to determine the particular genus of that family. The third and last step is to turn to the treatment of the genus, where (if more than one species is involved) a key to the species will usually be given.

Usually, it is not sufficient to accept the species name determined by the key as final. Confirmation is to be sought by comparing the plant in hand with the description of the species whose name was arrived at by the key. If there is not reasonably close agreement, the plant may have been misidentified and should be keyed again in a recheck for possible error. Experience gained in the use of the less complex keys, and similarly restricted floristic treatments of small areas, should provide a background and confidence to encourage one to use a more technical work like Fernald's *Gray's Manual* or Abram's *Illustrated Flora of the Pacific Coast States.*

PRESERVING MATERIAL FOR FUTURE IDENTIFICATION

As enthusiasm increases for knowing more kinds of plants, it will become evident that often it is not possible that each plant be studied as a freshly-picked specimen. Furthermore, there develops the desire to accumulate a record of the plants encountered, identified, and learned. This record takes one form or another of an herbarium. In its simplest form it may be that of cards on which are pasted fragments adequate to associate a plant with its name, or full specimens on sheets of regulation-sized herbarium mounting paper. These become recognition specimens. The other extreme is the preparation of conventional herbarium specimens pasted, complete with a label bearing collection data, on a 11½×16½-in. herbarium paper.

The basic principles are the same, whether preparing specimens for "recognition cards" or conventional herbarium specimens:

1. Flatten the specimen under pressure, selecting a plant that is typical and undamaged, and pruning or folding vegetative parts as needed;
2. Dry the specimen by pressure between sheets of newsprint and blotters, changing the blotters as they absorb moisture from the plant, or drying with heat.[1]

Equally important with preserving the specimen, is the preparation of notes of characters and conditions not evident from the dried specimens. These include:

(1) Place where collected, and date;
(2) Habit and size of plant (when the plant is too large to comprise the pressed specimen);
(3) Color of flowers and fragrance, if any;
(4) Color of fruit, when present;
(5) Type of habitat where the plant was growing.

Occasionally the non-botanist desires to know the identity of an unknown or to obtain verification of his own identification. This usually requires sending a portion of the plant to a botanical center, such as a botanic garden or college department of botany. The same procedures described above for preparing and preserving the specimen should be followed. Collection notes should accompany the specimen as an aid to the person identifying the plant. Elaborate pressing facilities are unnecessary. Most flowering material can be pressed and prepared for mailing by placing between several thicknesses of newspaper, and leaving under heavy weight (as a few books) overnight, and (leaving it in the newspaper) wrapping between two pieces of corrugated board (available from any carton of adequate size).

A second, and perhaps easier, method of sending material for identification is to place the specimen (folded in accordion-plaits if necessary) in an airtight polyethylene bag, such as is used for homefreezing of foods, and mailing it in a box to prevent undue crushing. Most plant material will keep well for three to eight days if so packaged. It is not desirable to moisten the specimen, nor wrap cut ends in wet material, when sending fresh material in moisture-proof envelopes of this type.

[1] For details on this and related techniques and procedures, see Lawrence, *Taxonomy of Vascular Plants*, pp. 234–248.

CHAPTER VI. *Nomenclature*

NOMENCLATURE is a function of taxonomy that deals with the determination of the correct name of a plant. In its more precise application it is associated with scientific or Latin names, but nomenclatural studies may also involve common or vernacular names. A plant must be identified and classified before it can be named, and it is important to distinguish clearly between identification and classification and nomenclature.

It is not uncommon to find that a plant may have different names in different floras or manuals. For example, one author may treat a plant as a species, and assign it a name. Another may believe the same plant to be only a variety of another species having an older name, and give it a varietal name. The determination of the category to which a plant belongs is a matter of classification. The correct name of the plant in one category (as that of species) may be different from the correct name it would receive in another category. The differences between some genera are not always sharp and clear cut, and it becomes a matter of opinion as to which genus a plant belongs; some authors may believe the plant to belong to one genus while some would place it in another—for this reason the plant would have one name by some persons and another name by others. However, when there is agreement on the correctness of the identification and the classification, there should be only one correct name for a plant.

Modern plant nomenclature, for the most part, dates from the eighteenth century. As the number of kinds of plants known to man has increased, the procedures for naming them have become more technical and legalistic. Today, many persons are familiar with the general mechanism of nomenclatural procedures, but so complex are some situations that only experts—persons who have devoted years of study to the subject—are held competent to resolve them. For this reason, this chapter makes no pretense to explore or explain the intricacies of nomenclatural problems. For them one is referred to the literature cited in *Taxonomy of Vascular Plants*, pp. 220–222.

Plants are not named haphazardly. For the last two hundred years the naming of plants has followed definite procedures. During this time, in response to new situations, these procedures have been modified, revised, and amplified. Linnaeus, the great Swedish botanist, laid down the first rules of modern nomenclature, doing so in 1737. For a century they remained relatively stable, but by 1867 communications had opened up areas of the world unknown to Linnaeus and his students, and resulted in the discovery, collecting, naming, and describing of tens of thousands of plants unknown to science in the mid-1700's. The revision of nomenclatural rules in 1867 was largely the work of Alphonse de Candolle, a Swiss botanist of great repute. As more areas became centers of western civilization, botanists came to be more conscious of their own international position and responsibility. In 1905 they held their third international congress in Vienna, when a new revision of a code of nomenclature was adopted. During this time a "splinter-group" of some American botanists attempted unsuccessfully to displace the international code and their differences of view were not reconciled until 1930. The present International Code of Botanical Nomenclature (hereinafter referred to as the ICBN) was adopted at the Seventh International Botanical Congress, convened in Stockholm, 1950, and is followed by botanists of all nations. It is to be expected that subsequent congresses will legislate changes in this Code.

One of the best ways to comprehend the scope of plant nomenclature and to appreciate its *modus operandi* is to study the more important provisions of the Code. This Code is divided into chapters, articles, and recommendations. For ease of reference the original numbers of the articles are used below, although not all comprising the Code appear in this brief recounting. The articles of the Code are considered binding on all who accept it. The recommendations are provided for guidance. In the Code, almost all articles are accompanied by examples illustrating the application of the provision. This Code sets forth the principles of plant nomenclature (Articles 1–21) and the specific rules by which they are activated (Arts. 27–83).

The principles provide that botanical progress is predicated on a universally accepted system of nomenclature that has for its objectives (1) the fixity of names, (2) nomenclatural clarity and freedom from ambiguity, and (3) the avoidance of the useless creation of names (Arts. 1–4). It deals with the categories of plant classification and the names applied to the taxa assigned to them (Art. 8). Botanical nomenclature is independent of zoological nomenclature, and there are many instances of plant genera and animal genera having identical scientific names. The scientific name of a plant is its Latin name, one taken from Latin (e.g., *Digitalis,* meaning glove-finger) or from Greek (e.g., *Lithospermum,* meaning stone-seed), or is treated as if Latin (e.g., *Lindera,* latinization of Linder, for John Linder, a Swedish physician).

The purpose of giving a name to a plant, or taxon, is solely to supply a means of referring to it and not to indicate its characters or history. For example, the name of the common milkweed is *Asclepias syriaca,* a native of eastern North America, although its name would imply a Syrian origin. The Latin name, *Asclepias syriaca,* is the species name. It is a binomial. For explanation of species names and binomial nomenclature, see Chapter III, p. 23.

The names legitimate, illegitimate, valid, and invalid are constantly encountered in nomenclatural discussions. A *legitimate name* is one that is in accordance with the Code. It is the correct name. An *illegitimate name* is one that is contrary to the Code, an incorrect name. It is provided that illegitimate names, such as *nomina nuda* (naked names, those not provided with descriptions) may not be included in nomenclatural considerations. A *valid name* is one that has been properly published. One may be obliged to consider several valid names to determine which is the legitimate name for a plant. An *invalid name* is one that does not meet all requirements for valid publication and as such is also an illegitimate name. The terms valid and legitimate are sometimes but improperly used interchangeably and thereby cause confusion. It is important to recognize these distinctions between them.

The Code is specific in designating the categories or units of classification and the sequence in which they are related to one another. The plant kingdom is divided into divisions and it depends on whose classification is followed as to what name is employed (e.g., some authors treat the vascular plants as composed of two divisions, the *Pteridophyta* and *Spermatophyta,* others may accept the view that taxonomically these represent but a single division, and call it the *Tracheophyta*). The practice of designating these taxa as *phyla,* as is allowed for divisions of the animal kingdom, is contrary to the Code. The units of classification have been treated in Chapter III and only the nomenclatural provisions for genera and lower units will be reviewed here.

The genus is composed of species, but for clarity in classification the Code provides for a number of infrageneric categories in the following sequence of descending magnitude: subgenus, section, subsection, series, subseries.

The name of a species is a binary combination consisting of the name of the genus (as *Quercus* for the oak) followed by the single specific epithet as the epithet *alba*, forming the binomial *Quercus alba* (the species name of the white oak). *Quercus alba* is the species name, known also as a binomial, a name of two words.

Provision is made for three infraspecific categories of the species: the subspecies, variety, and form.

From the above and the aspects covered in Chapter III, it should be clear that every species belongs to a genus, every genus to a family, every family to an order, every order to a class, and every class to a division. This sequence of categories is specified by the Code and cannot be altered.

The principle of priority is a cornerstone of the Code. It provides that each taxon from the rank of order to genus has only one correct name, the earliest published with the same rank. "For any taxon below the rank of genus the correct name is the combination of the generic name with the earliest available legitimate epithet or epithets validly published with the same rank" (Art. 16). There is one exception to this principle of priority for generic, family, and ordinal names. It is the provision (Art. 24) to avoid disadvantageous changes of names, whereby the Code provides lists of generic names retained as exceptions to the application of the rule of priority. The retained name is a conserved name (*nomen conservandum*) and any other name for that taxon is a rejected name (*nomen rejiciendum*). Efforts to extend the provisions of this rule to cover the conservation of species names have been defeated.

Names of all taxa are based on *types*. This is known as the application of the *type method*. The nomenclatural type of a species is a specimen, usually a pressed and dried herbarium specimen. If it is the one designated as the type by the author of the species, it is termed a *holotype;* if it is one from original material from which the species was described it may, if the author failed to designate a holotype or if the latter has been lost or destroyed, be designated as the *lectotype;* and if it is a specimen that was not known to the author of the name but (in the absence of any holotype) is selected by another person as typifying the species, it is designated as the *neotype.* The type of a genus is a particular species of that genus. Usually it is the first species to have been described in the genus or it may be the species on which the genus was based. The type of a family is a genus, that of an order is a family, etc.

The publication of names is a subject that is strictly legislated by the Code. There are two aspects to the publication of scientific names: effective publication and valid publication. *Effective publication* refers to the place and the scope of publication. Until January 1, 1953, a name could be published anywhere—a book, a magazine, on a printed herbarium label of a widely distributed collection, in a newspaper, or a nursery or seed list. The rules now reject names published since January 1, 1953, in newspapers or tradesmen's catalogues. To be effective, the name must also be published in a book or periodical that is distributed to botanical centers throughout the world in some indelible form. Publication by communication of new names at a public meeting, or by annotation of collections, or by issue of microfilm of otherwise unpublished manuscripts, does not comprise effective publication. On and after January 1, 1953, a name is not effectively published if printed on a label and accompanied by a description and distributed widely with specimens of that name.

Valid publication requires that in addition to being effectively published, the name must meet one or the other of the following two conditions: (a) it must be accompanied by a description of the taxon (in Latin if published on or after January 1, 1953); or (b) it must be accompanied by a reference (direct or indirect) to a previously validly published description. The first condition should be self-explanatory. The second may be less obvious and requires illustration:

The species *Rhododendron candense* was so named by John Torrey in 1839, but it was first given a binomial by Linnaeus in 1762 who named it *Rhodora canadense* and accompanied the name with a description. According to the Code it was correct for Torrey to validate his transfer of the plant from the genus Rhodora to the genus Rhododendron by following the new name with a reference to the binomial used by Linnaeus (the basic name or basonym) and to Linnaeus' description. On and after January 1, 1953, new transfers, such as this, are validly published "only when the basonym . . . is clearly indicated with its author and the place and date of publication" (Art. 42).

The citation of authors' names is provided for in the Code (Arts. 55–60). In floras, manuals, and technical works, the scientific name of a taxon is followed by the name (often abbreviated) of the person who first described it. This increases the precision and accuracy of the treatment. For example, in 1753 Linnaeus named the red maple *Acer rubrum*. To distinguish this from a different species of maple, but given the same name by Lamarck in 1788, one writes it *Acer rubrum* L. It is known now that Lamarck's maple is the same species as that named *Acer saccharinum* by Linnaeus in 1753 and one would treat Lamarck's name as a synonym of *Acer saccharinum* and write it "*Acer rubrum* Lamarck (1788), not L. (1753)." By citation of these authors' names, clarity and accuracy is added.

Article 58 of the Code reads, "When a name has been proposed by one author . . . and is subsequently validly published and ascribed to him by another author who supplied the description, the name of the latter author must be appended to the citation with the connecting word *ex*." The Oak, *Quercus hemisphærica* was named, and perhaps described, by John Bartram of Philadelphia, but the name was published by Karl Willdenow of Berlin in 1805, not by Bartram. To distinguish between the author of the name (Bartram), and that of the publisher (Willdenow), the binomial and its author citation is *Quercus hemisphærica* Bartram ex Willdenow. For brevity this may be condensed to *Quercus hemisphærica* Bartram.

For situations where a genus, species, or taxon of lower rank "is altered in rank but retains its name or epithet, the author who first published this name or epithet must be cited in parentheses, followed by the name of the author who effected the alteration" (Art. 59). This is sometimes called double author citation. For example, in 1814 Frederic Pursh named a California shrub *Arbutus tomentosa*. Twenty-two years later John Lindley, of London, recognized it as a member of the genus Arctostaphylos and made the new combination of *Arctostaphylos tomentosa* (Pursh) Lindley. Pursh's name in parentheses shows he had given the taxon the epithet *tomentosa* in another genus or category, and Lindley's name following shows that he was responsible for the transfer. A second example shows the same application if an epithet is retained when a taxon is transferred from one category to another: A shrub was named *Ceanothus integerrimus* var. *parvifolius* by Sereno Watson in 1875. Later, William Trelease recognized it as a distinct species and named it *Ceanothus parvifolius*. Since it is based on Watson's type, and since Trelease retained Watson's epithet, the binomial and its full citation is *Ceanothus parvifolius* (S. Watson) Trelease.

Retention of epithets of taxa usually prevails when names are transferred *without change of rank*. When a species is transferred from one genus to another, the epithet must be retained unless the resulting binomial is (1) a later homonym (duplication of an earlier name for a different plant), (2) a tautonym (duplication of generic name as the specific epithet, as *Pinus Pinus*), or (3) unless there is available in the genus an earlier validly published specific epithet. These same rules apply to the transfer of taxa below the rank of species, provided no change of rank takes place.

The uniting of two or more taxa of the same rank results in retention of the oldest name or epithet. When two or more taxa of different rank are united, the earliest legitimate name or epithet in the new (accepted) category is correct. In no case does a name or epithet have priority outside its own rank. To illustrate, the name of the variety of ash now known as *Fraxinus pennsylvanica* var. *subintegerrima* (Vahl) Fernald was long treated as *F. pennsylvanica* var. *lanceolata* (Borkh) Sargent. However, the epithet *lanceolata* had its origin in the species name or binomial *Fraxinus lanceolata* Borkhausen (1800). This taxon bearing the epithet "lanceolata" was first treated in the rank of variety by Sargent in 1894. If the plant is accepted as a variety, the oldest epithet assigned it in the category of variety must be used: that epithet is *subintegerrima*, given by Vahl in 1804. Vahl's name is placed in parentheses because he mistook the plant to be a variety of *Fraxinus juglandifolia*. Fernald made the transfer to *F. pennsylvanica*, hence his name follows Vahl's.

The Code recognizes numerous situations under which names or epithets must be rejected. When rejected, the name is replaced by the next oldest legitimate name or, if there is none, it is replaced by a new name. In this connection it must be remembered that a name may not be rejected "merely because it is inappropriate, or disagreeable, or because another is preferable or better known, or because it has lost its original meaning" (Art. 72).

A name must be rejected if it is illegitimate, and nomenclatural illegitimacy exists if:

1. it was superfluous when published (that is, if another and legitimate name already existed in the accepted rank);

2. the earliest legitimate epithet in the particular circumscription, position, and rank had not been adopted;
3. it is a later homonym (that is, if it duplicates a name previously published for a taxon of the same rank but based on a different type, even if the earlier homonym was illegitimate);
4. it is a tautonym;
5. it is a binomial published in works in which the Linnaean system of binomial nomenclature was not consistently used for species.

The Code makes other provisions by way of its Recommendations. Those most commonly encountered deal with the subject of capitalization of specific and ternary epithets. On this subject the present Code is essentially noncommittal, Recommendation 82 g providing:

All specific and infraspecific epithets should be written with a small initial letter, though authors desiring to use capital initial letters may do so when the epithets are directly derived from the names of persons (whether actual or mythical), or are vernacular (or barbaric) names, or are former generic names.

The use of the single and double "i" is another source of confusion and is covered by Recommendation 82 c (1),

When the name ends in a consonant the letters *ii* are added (*Ramondii* from Raymond), except when the name ends in *-er,* when *i* is added (thus *Kerneri* from Kerner). Those who follow this Recommendation may treat the termination *-i* as an orthographic error and correct it.

There is another nomenclatural situation that is inextricably interlocked with taxonomy and which is a source of confusion to many budding taxonomists. That is the recognition and naming of the typical element of a species. The typical element of a species is that which is indistinguishable from the type specimen of the species. If the species is so constant and so uniform in all characteristics that all plants appear to be like the type specimen then no problem of recognizing variants of the species is at hand. However, suppose you were the first to discover the species of maple known today as *Acer palmatum* and that you collect, prepare, and document an herbarium specimen of the species and publish the name and description in accordance with the rules. That specimen is the type of the species. As an aid to visualizing this type, assume it to be represented by Fig. 43 a.

Let us extend the supposition further and assume that a year later on a Japanese mountain side you collected another maple. From its fruits and other characters you recognize it as *Acer palmatum,* yet its foliage is so different as to be distinct from the specimen first collected. Perhaps you consider it a variety of the first species and name it *Acer palmatum* var. *aconitifolium.* The type specimen of this new variety is the one you collected. Assume it to be represented by Fig. 43 b.

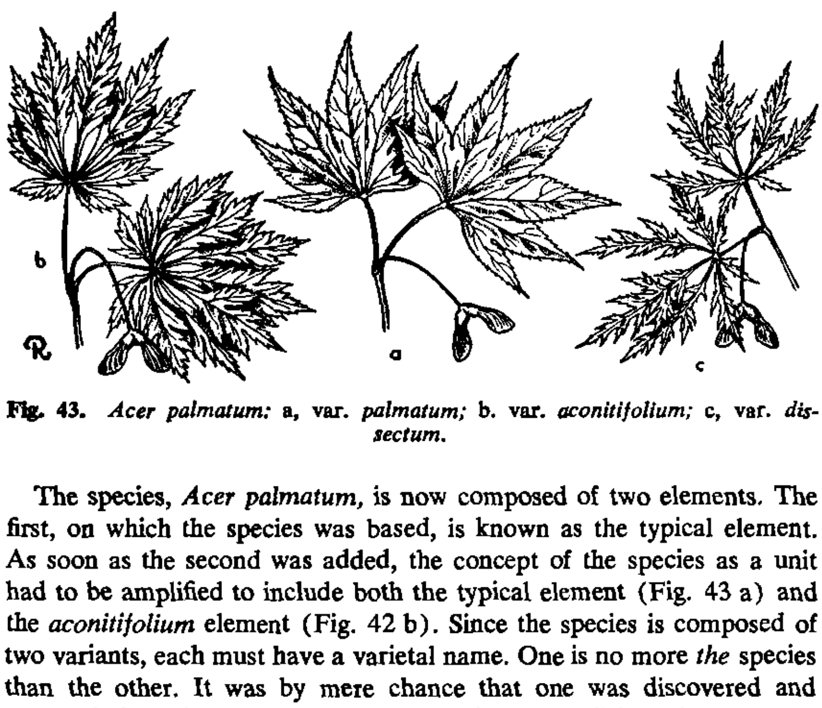

Fig. 43. *Acer palmatum:* a, var. *palmatum;* b. var. *aconitifolium;* c, var. *dissectum.*

The species, *Acer palmatum,* is now composed of two elements. The first, on which the species was based, is known as the typical element. As soon as the second was added, the concept of the species as a unit had to be amplified to include both the typical element (Fig. 43 a) and the *aconitifolium* element (Fig. 42 b). Since the species is composed of two variants, each must have a varietal name. One is no more *the* species than the other. It was by mere chance that one was discovered and named before the other. It becomes desirable to differentiate nomenclaturally, between the two. The Code provides for this by stipulating that the typical element of a taxon be designated by repeating the epithet of the taxon in the next higher category which is based on the same type specimen. By application of this rule, the name of the typical element of this maple becomes *Acer palmatum* var. *palmatum.* Because the type specimen of var. *palmatum* is that of the species (a species, no matter the number of its varieties, can have only one type specimen), it is not necessary to follow it with an author's citation. Its author is always that of the binomial. Prior to legislation of the present Code there was no uniformity in the naming of typical elements and authors designated them by such epithets as *typicus, genuinus*, or by prefixing *eu-* to the repeated specific epithet. Botanists are now directed to replace these epithets, as necessary, with that repeating the epithet of the next highest taxon based on the same type specimen.

In most works written more than a half-century ago, and some of more recent time, authors described the species in the sense of the typical element and treated varieties as if they were appendages of the species. These authors did not conceive the species as a biological unit composed of variable populations. They did not treat the first-named population as a typical element. For this reason, in a majority of current floras and manuals the typical element of a highly variable species may not be accorded nomenclatural recognition.

The nomenclature for cultivated plants must conform to that provided for native plants insofar as the same classificatory situations prevail. However, the many specialized situations encountered with cultivated plants have resulted in the formation of an Appendix VIII of the ICBN. This Appendix, known also as the *International Code of Nomenclature for Cultivated Plants*, was presented at the Stockholm Congress in 1950. It was later adopted, with some revision, by the international committee on horticultural nomenclature and registration at the Thirteenth International Horticultural Congress, London, 1952.

This review of plant nomenclature, and of the major provisions of the ICBN, increases one's appreciation of the principles involved and should help one to understand that there are usually good reasons for occasional changes of plant names. In this connection, it is imperative to distinguish between changes resulting from processes of classification and identification and those due to application of the rules. If the name change results from a change of rank of a taxon, it is one of classification; if from a change from affiliation with one genus to another it may be one of identification. An analysis made by me in 1949 of changes of about 120 plant names showed that about one-third represented the application of the "Rule of Priority," the displacement of an existing name by an earlier legitimate name; a fourth represented the application of the "Homonym Rule" (Art. 72), the displacement of a name because it had been used previously for a different kind of plant; and the balance of the changes represented a variety of taxonomic rather than nomenclatural reasons, including misidentification by earlier authors, the subdivision of genera into two or more genera, and the uniting of two or more genera under one name

CHAPTER VII. *Phylogeny and Biosystematics*

PHYLOGENY is the evolutionary history of a taxon, and by the principles of phylogeny the attempt is made to account for the origin and development of the taxon. In much of the literature the term phylogeny has become associated more with studies of major units of classification (as the family and units above it) than with the genus and infrageneric units. This distinction is artificial, because studies of the evolutionary history of the species and its subdivisions may be as truly phylogenetic as those dealing with higher units. Biosystematics, on the other hand, is a study of living populations with the objective of recognizing and circumscribing natural biotic units (quite different from conventional taxonomic units), and to classify them objectively as taxa of different orders of magnitude. The casual reader may think these two topics as strange bed-fellows to be combined in the same chapter but this is not the case. They represent two different approaches to the same goal: the formulation of a classification based on genetic or natural relationships.

The primary objective of phylogenetic studies is to determine the origins and relationships of all taxa of extinct and extant plants, and from these data to prepare a classification reflecting these relationships. This is a goal. Such a classification does not exist today, and there is scant probability that it ever will exist. Why not? Because much, in fact most, of the evidence establishing the identity of ancestors of present-day plants is believed to be nonexistent, and it is not likely that substantial portions that may be buried beneath the earth's surface ever will be recovered or past history reconstructed. Without these data, present and future systems of classification must be largely conjectural.

PRIMITIVE VS. ADVANCED CHARACTERS

Phylogenetic studies have attempted to determine, among other things, which characters of present-day vascular plants have remained substantially unchanged during the geologic ages and epochs of evolution. A character that has persisted for long periods is said to be conservative or primitive. The terminal position of the ovary on a branch or axis is an example of a conservative character. One of the best sources of evidence for primitiveness of characters (or of taxa) is in the fossil record, for here there are paleontological data of plants of former times. Unfortunately these data are very few, and for flowering plants, fossils have not produced much conclusive evidence. Contemporary taxonomic writings may designate certain characters as primitive and others as advanced (of later evolutionary development), but with few exceptions these are only allegedly or presumably primitive or advanced. The evidence in this regard is more often circumstantial, or even only speculative, than factual. Very often the evidence that is available serves as the basis for certain deductions compatible with the general theory of evolution. The synthesis of data from many sources often contributes to a series of deductions relating to possible and plausible phyletic views that seem to be in greater harmony with known facts than are earlier views. By these additive processes our ideas of phylogeny take on a three-dimensional character, and there follows the recognition that plant relationships are not simply tree-like in their composition but are further complicated by having the branches interlocked in a reticulate fashion.

A trend is now gaining momentum to place greater confidence in the conservative nature of anatomical characters, especially of the vascular anatomy. The type of stele within a stem, the presence and nature of leaf-gaps, of orientation of vascular strands, and the vestigial remains (or presumption of such) are now subject to greater use than ever before in determining allegedly primitive conditions. Acceptance of these views has led to the belief that organs or plants that today may appear simple are in fact seemingly simple by reduction or loss of parts. Anatomical evidence is usually presented in support of such views. If accepted, it holds that these seemingly simple structures or plants have come from ancestors that were more complex as concerns number of parts, hence the seemingly simple situation represents an advancement over the earlier and more primitive condition. An illustration of this is to be found in the catkins of birch, or alder, or hornbeam; inflorescences now seeming simple, but adduced to be simple by reduction and fusion of parts from ancestral types—inflorescences not simple but highly complex and advanced.

A classification may be phylogenetic or it may be strictly artificial No truly phylogenetic classification exists today for the vascular plants or the flowering plants, or the monocots, or for any order of this taxon. Undoubtedly some monographic works of some genera have been so thorough as to be able to classify the species of a genus in as nearly a phylogenetic classification as possible. Other things being equal, the lower the classification unit (as species is lower than genus) and the smaller the number of taxa composing it, the more likely it is that a phylogenetic classification of its taxa can be closely approached.

In the absence of paleobotanical data, the phylogenist dealing with higher units of classification seeks to piece together an evolutionary pattern of ancestry by using as many other data as possible. These are obtained from studies of anatomy, morphology, cytology, genetics, and physiology of the plants concerned. Structures and organs too minute to be of use in identification procedures are often very important, especially those associated with the embryo, pollen, chromosomes, floral vascular-anatomy, and the seed.

By application of these techniques, it is now held that the inferior position of the ovary is derived from ancestors in which the ovary was superior, that flowers possessing a gynoecium of one or a few pistils may have been derived from those whose gynoecia were of many pistils, that the simple ovary with marginal placentation preceded the compound ovary with axile, parietal, or free-central placentation, etc. These studies have also led to the belief that possession of certain characters of two or more major taxa may be evidence of parallel evolution and not necessarily of close or common relationship. To illustrate, a polypetalous type of corolla is generally held to be more primitive than the gamopetalous type. By the Engler or the Bessey system of classification all taxa with gamopetalous corollas belong in one sector of each system, on the assumption that this condition arose once long ago by convergent evolution, that is, by convergence of evolutionary products and the "fanning out" from that convergence of subsequent taxa possessing the character in common. Evidence is continuing to accumulate to refute this view, and to support the opposing view—that by parallel evolution the condition of gamopetalous corollas has arisen many times among flowering plants and among taxa phyletically far removed from one another.

Phylogenetic studies at the level of the family and above result in modifications of existing systems or in the formulation of new systems of classification. That is why it is now believed by many botanists that the systems of Engler and of Bessey are so "out of date" that neither reflects a synthesis of the most acceptable data available. New systems have been presented since these, but none has been adopted widely; more new systems and revisions of systems are inevitable and will become subjects of biological importance. The new and successive systems have their place; each is to be studied, tested, and analyzed. None may displace existing systems in our major herbaria or floras, because the taxonomist can identify, name, and catalogue (i.e., classify) his plants without phylogeny. Phylogeny leads to a better understanding of relationships at all levels and thereby is a significant contribution to knowledge, but it is not essential to the demands on taxonomy as a functional science.

Biosystematics has the same goal as does phylogeny, but is concerned primarily with units of genus and below. Furthermore, it is a facet of taxonomic endeavor that is predicated on data obtained from the behavior of living individuals and populations. The biosystematist rejects most conventional taxonomic definitions of a genus or a species and tries to determine the circumscription of these taxa (or populations) more objectively. In doing so, emphasis is placed on cytogenetics and cytotaxonomy supplemented by the classical approaches of morphology, ecology, and phytogeography. Cytogenetics deals with the analysis of breeding behavior of individuals in the light of their chromosome complements, contents, and activity at meiosis. Cytotaxonomy is the integration of cytology—more properly termed karyology—and taxonomy in the effort better to understand and to resolve problems of plant relationships.

Biosystematic investigations include:

1. sampling of the taxon and the cytological study of its populations,
2. studies of the genetic compatibility of the populations and of the vigor and fertility of resultant hybrids in the determination of presence or absence of breeding barriers,
3. studies of the homologies of the chromosomes in the hybrids at time of meiosis,
4. integration of above data with those obtained from comparative morphology and geographical distribution,
5. subjection of individuals or populations thus studied to criteria of a system of classification into biosystematic units.

The biosystematic categories have been devised in the effort to produce a better understanding of natural relationships at the rank of genus and below. They are categories that may be counterparts of taxonomic categories but are never to be used as substitutes or equivalents of them. They have no status in the formal nomenclature of plants. Each provides a single-word term for a biosystematic situation. The categories (and their approximate phyletic level) are:

comparium—comparable to the genus

ecospecies—an approximation of the conventional and conservative species, and

ecotype—sometimes parallel with the geographic variety or subspecies of taxonomists.

In no case should any one of these terms be applied to a plant or population unless the situation for which the term stands has been proved experimentally to exist for the particular taxon. These biosystematic categories represent evolutionary nodes in the sense that each category represents a step or level in the evolutionary scale of differentiation from that of a local population to that of a genus.

The student requiring a more complete treatment of the subject of biosystematics is referred to Chapter VIII in *Taxonomy of Vascular Plants,* where the various biosystematic categories are described in detail (pp. 176–179) and the advantages and limitations of the techniques and results are discussed.

Biosystematic studies require facilities for field experimentation, for research studies of clonal separations of individuals under different environmental conditions, and for cytogenetic experiment. They are time-consuming and costly. Results obtained have contributed materially toward the solution of numerous taxonomic problems and "riddles" not otherwise resolved. They may provide one avenue of approach to some difficult taxonomic groups. For other groups they have been found to be of little help—as in solving problems of taxonomic relationship and speciation in such genera as *Lathyrus* or *Astragalus.*

These experimental channels provide the taxonomist with one more and very valuable tool with which to work, but it must be recognized that biosystematic studies of themselves are not likely to provide the answer to a majority of the taxonomist's problems of speciation and determination of generic limits.

CHAPTER VIII. *Taxonomy in North America*

WHENEVER a student of North American plants makes use of floras, manuals, or technical papers he encounters the names of the men who described these plants, or of men whose names are associated with binomials or important floristic works. It is not enough to know the plants and their biology; the taxonomist profits from knowing something of the past that has contributed to the heritage of the science—a heritage built around the lives and accomplishments of the men concerned.

The beginnings of taxonomic botany in North America cannot be separated from botanical studies in Europe of the same period. In the earliest days of New World exploration and colonization, tropical American plants were known to Europeans to a greater extent than were those of temperate regions. Sir Francis Drake sent plants back to England from tropical America in the sixteenth century. Robert Morrison (1620–1683) of England and Botanist to the king, wrote three volumes on plants in the Royal Gardens. Many of these plants were of American origin.

The first book devoted to North American plants was *Flora virginiensis* written by John Frederick Gronovius and published in 1739–43 in Holland. Gronovius, friend and onetime counselor of Linnaeus, based this flora on extensive notes and a collection of pressed plants received in 1730 from his American correspondent John Clayton of Virginia. A second and much revised edition, based on the Linnaean system, but using polynomial nomenclature was published in 1762. The work is of historical interest, for the first edition was cited regularly by Linnaeus in *Species Plantarum*. Some of Clayton's plants are now at the British

Museum (Natural History) in London, and not a few are the types of Linnaean species. Clayton is commemorated by the genus *Claytonia* (Portulacaceae).

John Bartram (1699–1777), a Philadelphia Quaker, laid out and planted one of the first arboreta in this country. He was a correspondent of many European botanists, notably Peter Collinson of London, and to whom he sent specimens, seeds, and plants of a large number of American species and genera. His travels for plants took him as far south as Florida and as far north as Lake Ontario, New York. The moss genus, *Bartramia,* was named in his honor.

Another Philadelphia Quaker and contemporary of Bartram's was Humphrey Marshall (1722–1801), also a dendrologist, who published (1785) a small book on American trees entitled *Arbustum Americanum.* Marshall named many species but by modern standards his descriptions are neither ample nor critical. He followed the binomial system of nomenclature and arranged the plants in alphabetical sequence. Marshall was for many years a correspondent of Sir Joseph Banks of London and sent to him seeds and roots of many American plants. The genus *Marshallia* (Compositae), often credited as having been named in honor of Humphrey Marshall, commemorates his nephew, Dr. Moses Marshall (1758–1813), who was more important as a collector and exporter of plant materials than as a scientist.

Peter Kalm (1716–1779), Swedish naturalist, student and associate of Linnaeus, spent three years in eastern North America and, perhaps more than any other person, provided Linnaeus with valuable collections of plants from this region. These specimens are now to be seen in the Linnaean Herbarium in London. His account of travels from Philadelphia south through Virginia and north to Canada have been translated into English. In identifying and naming Kalm's collections, Linnaeus used the epithets "*canadensis*" and "*virginiana*" frequently and loosely as the two principal localities in North America, without regard for the limits of the political subdivisions. The genus *Kalmia* (Ericaceae) named by Linnaeus commemorates Peter Kalm.

Thomas Walter (*c.* 1740–1789) emigrated from England to eastern South Carolina, but little is known about his background or life. Remote from cultural centers, libraries, or associates in science, he wrote a flora of the region in Latin and named it *Flora Caroliniana.* It was based on his own collections, augmented by some of John Fraser's, and the manuscript, together with Walter's herbarium, was taken by Fraser to

London in 1788. Fraser published Walter's flora at his own expense, and it was the second floristic work of its kind devoted to a region of this country. It treats about 1,000 species and 435 genera; 200 species were described as new. Whenever Walter had a plant whose generic position was unknown to him, he resorted to the curious device of placing it in his genus *Anonymous* and made many binomials therein (e.g., *Anonymous plicatus, A. rigidus*). As the generic position of these species became known to later authors, many of the epithets were transferred to the correct genus, with Walter acknowledged as the parenthetical author. The International Code of Botanical Nomenclature (1952) rejects these basonyms. Subsequent combinations based on the Walter epithets in *Anonymous* can no longer be treated as legitimate if antedated by another legitimate name for the same plant. Walter's herbarium, a bound volume of snips and scraps, was given by Fraser's descendants to the Linnaean Society of London in 1848, and by the latter in 1863 to the British Museum (Natural History), where it is now available for study.

Period of 1800–1840

This period was one of active exploration along the Atlantic coast and Allegheny Mountains and westward into the Mississippi drainage basin. The three most notable botanists of the period were Pursh, Rafinesque, and Nuttall.

Benjamin Smith Barton (1766–1815) was more important as a teacher and benefactor of botany (at the College of Philadelphia, antecedant of the University of Pennsylvania) and physician than as a publishing taxonomist. His *Elements of Botany* (1803) was one of the first American works of its kind. Much of his research dealt with problems of pharmacognacy and *materia medica*. He was responsible for some of the work of Pursh and Nuttall. The genus *Bartonia* (Loasaceae) commemorates his name.

Jacob Bigelow (1786–1879), a Boston physician, published the first good flora of the New England area, *Florula Bostonensis*. The first edition (1814), based on the Linnaean system, was restricted to the plants growing within ten miles of Boston, but the next (1824), based on the de Candollean system, accounted for most of those of New England. Bigelow's most valued contribution is considered to be his three-volume work *American Medical Botany* (1817–20). *Bigelowia* (Compositae) was named in his honor by de Candolle.

William Darlington (1782–1863), another of the Philadelphia botanists, and pupil of Barton, was a physician of note. As a botanist he published a *Florula Cestrica* (1826), a catalogue of plants in the region of West Chester, Pennsylvania, of which a revised, enlarged and annotated edition was later published under the name of *Flora Cestria* (1837); in the first edition he adopted the Linnæan system of classification, and in the second the de Candolle system. His *Agricultural Botany* (1847) was one of the first American works to name and describe cultivated plants. Torrey named the genus *Darlingtonia* (Sarraceniaceae) of California in his honor.

Gotthilf H. E. Muhlenberg (1753–1815), a Lutheran clergyman, was a teacher and botanist of Lancaster, Pennsylvania, and was a specialist in the taxonomy of grasses, sedges, and fungi. His *Catalogue Plantarum Americae Septentrionalis* (1813) was the first comprehensive account of the then known native and naturalized plants of North America (arranged according to the Linnaean system). Previous works were of more restricted scope. He collected assiduously, accumulated a large private herbarium that was especially strong in sedges and grasses, and was the author of scores of new species names in these families, of which many binomials were published for him by de Candolle. *Muhlenbergia,* a genus of grasses so named by Schreberer, commemorates his name. Probably no American botanist of the period had a wider circle of foreign botanical correspondents than did Muhlenberg. Unfortunately, a major part of his herbarium was ravaged by insects, and many types were lost. The remains of this collection are at the Academy of Natural Sciences, Philadelphia.

André Michaux (1746–1802), a French botanist and student of Bernard de Jussieu, was sent by his government to this country in 1785 to collect material for the botanic gardens in Paris. He settled in Charleston, South Carolina, in 1787, and stayed there for ten years. He traveled during this time over much of the eastern part of the country. During this period he introduced about 60,000 American plants to French and Austrian gardens. He published (1801) the first work on the oaks of North America and in 1803 there was published under his authorship the first flora of North America, *Flora Boreali-americana. Michauxia,* a campanulaceous genus, was named for Michaux by L'Heritier.

François André Michaux (1770–1885), son of André, and a more talented botanist than his father, published his North American sylva

Histoire des arbres forestiers de l'Amerique septentrionale . . . in three volumes in 1810–13. Here, many species of forest trees are named and described for the first time. François André was in this country for three different, but short periods, returning to France for the last time in 1809. He was better known in the United States than in France and bequeathed a part of his fortune to the American Philosophical Society, Philadelphia.

Frederick Pursh (1774–1820), of Saxony, Germany (not Siberia, as often recorded), emigrated to the Philadelphia area in 1799 as a gardener and profited from the patronage of Humphrey Marshall and Benjamin Smith Barton. He lived in poverty most of his life and died at the home of a friend in Montreal while working on a flora of Canada. He travelled some in eastern North America, collected extensively, is alleged to have pirated collections of others and to have published their new species as his own. In 1811 he went to England where (in 1814) he arranged for the publication of his two volume *Flora Americae Septentrionales,* the second comprehensive flora of North American plants. It contains no keys and the descriptions are very brief. Many new species were described; it nearly doubled the number of species known to Michaux. Pursh included here also the plant records of the Lewis and Clark expedition to the Pacific Northwest. Many of Pursh's specimens are in the herbarium of the Academy of Natural Sciences, Philadelphia.

Thomas Nuttall (1786–1859) came to Philadelphia from Yorkshire, England, in 1808, as a journeyman printer. During his first year in America, and with counsel from Benjamin Smith Barton, he became avidly interested in knowing the local flora and travelled in adjoining states searching for plants. He accompanied Bradbury, a Scotch naturalist, to the upper limits of the Missouri River and brought extensive collections of plants back to Philadelphia. For the next eight years he travelled over much of the eastern half of the country making Philadelphia his winter headquarters. It was during this period that he completed his two-volume work *The Genera of North American Plants, and a catalogue of the species to the year 1817* (published in 1818). This was the first work of its kind and is noted for its meticulousness and accuracy. Nuttall himself set the type for the two volumes. From 1822–1833, Nuttall was curator of the Botanic Garden at Harvard but was not happy with so sedentary a life. In 1834, in company with John K. Townsend, he went overland to Oregon, down the Columbia River to

Fort Vancouver, on to the Hawaiian islands, and back to Philadelphia late in 1835 by way of Cape Horn. In 1841, he returned to England to claim a legacy granted on the condition that he maintain his residence there for nine months of every year. Prior to leaving Philadelphia, he published a three-volume supplement to Michaux's *Silva* which he titled *The North American Silva* (1842–54). Elias Durand summarized Nuttall's work by writing, "No other explorer of the botany of North America has personally made more discoveries; no writer on American plants, except perhaps Asa Gray, has described more new genera and species." The genus *Nuttallia* (Rosaceae) commemorates his name. Nuttall's plant collections contain a large number of types, and, while many have been lost, those extant are at the Academy of Natural Sciences, Philadelphia, and the British Museum (Natural History), London.

Constantine Samuel Rafinesque (Schmaltz), was born in 1784 in Constantinople of French and German parents and spent much of his early life in southern France and Sicily. Rafinesque, as he is best known, is one of the world's most controversial botanists. He was a genius, yet an erratic eccentric, an egoist who was vain, ambitious, and contentious to a fault. His egoism, fired by an inexhaustible energy, engendered in him a passion that he be recognized as the supreme naturalist, a conviction that drove him to write voluminously, not only in the fields of geology, zoology, botany, and the physical sciences, but also in philosophy, religion, and metaphysics. Dr. E. D. Merrill has written of him, ". . . he lived to publish." The opinion that he was a psychopath is not restricted to his contemporaries, but it may be unduly severe. Certainly he has not always been treated fairly. It is unfortunate that his publications in descriptive biology were so consistently ignored by his contemporaries and immediate successors. Much of his botanical work was of merit. He published several floristic works of nomenclatural importance. One of these, *Florula Ludoviciana or Flora of the State of Louisiana* (1817), was of a locality he never visited nor whose plants had he studied. In this work he based his descriptions on the scant notations of a French author's *Flore Louisianaise* (1807). Many of his contemporaries, and botanists of the succeeding generation (including Asa Gray), ignored his writings. Of recent time greater study has been given to Rafinesque's work, notably by E. D. Merrill of the Arnold Arboretum, and although Rafinesque left no herbarium, many of his descriptions and names have been identified. Merrill's *Index*

Rafinesquenorum (1949) has become indispensable to all students of Rafinesque names. The genus *Rafinesquia* of Compositae was named in his honor by Nuttall, and on one occasion, perhaps in fear his name might not be so perpetuated, Rafinesque himself renamed a species of *Jacaranda* (Bignoniaceae) as *Rafinesquia!*

Period of 1840–1880

Two American botanists tower over all others for this period: John Torrey and Asa Gray. Each was trained as a physician, but Gray did not practice the profession. This period was one of great exploration throughout the central and western parts of North America and one that was paralleled by colonial exploration in the Old World by the British (Australia, India, South Africa). It was the period of rapid ascendancy of taxonomic work at the Royal Botanic Garden at Kew, England, and the British Museum, London. At Kew, such men as John Lindley, William J. Hooker and his son, Sir Joseph D. Hooker, and George Bentham, made their mark with monographic and floristic studies. Robert Brown was a leader of similar research at the British Museum. The personalities and accomplishments of these British botanists provided a background of influence to their American counterparts. Exchanges of ideas, publications, and specimens were a continuing process.

John Torrey (1796–1873), state geologist for New Jersey, chemist, Professor of Medicine at Columbia University for thirty years, and botanist outstanding, published two floras, each of two volumes, on the higher plants of eastern United States. One was *A Flora of the State of New York* and the other, in collaboration with Asa Gray, *A Flora of North America* (1838–43). Torrey was a critical taxonomist, more thoroughly trained in science than any American predecessor. He recognized the value of type specimens, studied them in European as well as in American herbaria, and reviewed the literature with meticulous care. He early discarded the Linnaean system for that by de Candolle, was one of the first to provide ample descriptions of accepted taxa, supplementing them often with ecological notes, and keys as aids to identification and diagnosis. Torrey was the dominant figure in American botany. He was a man whose views and help were sought by others working with the lower groups as well as the ferns and seed plants. His name is commemorated by the genus *Torreya* (Taxaceae), so named by Arnott of Scotland.

Asa Gray (1810–1888) born near Utica, New York, was a precocious student, trained as a physician but more interested in plants than in medicine. While a student he corresponded with Amos Eaton, Rensselaer Polytechnic Institute, Troy, New York (author of *Manual of Botany for the Northern States,* 1817). Eaton referred him to Dr. Torrey whom Gray visited in 1832. As a result of this visit, Gray accepted Torrey's invitation to be joint author in the preparation of the *Flora of North America.* From 1840 to 1880, Gray was Fisher Professor of Natural History at Harvard. Here he specialized in taxonomic studies on the plants of eastern North America, of western North America, and of Japan. Evidence of the quality of his work is found in the large number of the many species described by him as new and which are currently accepted both as to name and to rank. Gray was also an outstanding teacher, and his books *First Lessons with Plants* and *Structural Botany* continue to be consulted, although long since out of print. In 1880 he commenced publication of his *Synoptical Flora of North America,* in which he proposed to include, with synoptical keys, descriptions of every species of flowering plant then known for the region. Gray died in 1888, before the completion of this work. The genus *Grayia* (Chenopodiaceae) of the southwestern part of the United States commemorates his name.

With his death in 1888 Harvard's position as the dominant American center of taxonomic thought came to an end. During Gray's (and thus Harvard's) era of dominance, this country was expanding and students of Gray and others were establishing new centers of taxonomic activity. These successors, in point of time, may be treated as representing two basic schools of thought: the Harvard School and the New York School.

The Harvard School, 1880–

Asa Gray was influenced considerably by Sir Joseph D. Hooker and other British taxonomists. Their views on classification, nomenclature, and concepts of classificatory units (especially of species and genera) were accepted in principle by him. Many students profited from Gray's teachings, and other young botanists worked in association with him if not as students, e.g., Charles E. Bessey. These colleagues of a succeeding generation continued the Grayian ideas.

At Harvard, Asa Gray had Sereno Watson (1826–1892) first as his assistant (in 1873) and later as curator of the herbarium (from 1874 to Watson's death). Watson, a graduate of Yale, was in California in

1867 and there joined the King exploring expedition. It was the exce lence of his specimens and of his five-hundred-page report, *Botany c the King Expedition,* that brought Watson to Gray's attention. This re port by Watson became in effect the first flora of the Great Basin. Hi two-volume *Botany of California* (1876–80) stood for several decade as the most complete flora of that region, and his *Bibliographical Inde. to North American Botany* (1878), a never-completed labor of love was another "first" by Watson. With John M. Coulter he prepared th revised fifth edition of Gray's *Manual of Botany.* Watson was a quie retiring man of dignity, a rapid worker, but not one to attract students

Benjamin Lincoln Robinson (1864–1935), a graduate of Williams Harvard, and Strassburg, became an assistant to Watson in 1890 anc succeeded—on the death of Watson—to the post of curator of the Gray Herbarium in 1892. Robinson "inherited" an institution wealthy ir specimens and books but lacking endowments, operating funds, or adequate housing. His was the responsibility of acquiring financial independence for the Gray Herbarium and for designing and financing the fireproof building that held its collections until 1954. During this time he worked over the collections and wrote the *Flora of the Galapagos Islands* (1902) and, with Fernald, prepared the entirely rewritten seventh edition of Gray's *Manual of Botany* (1908). Robinson's taxonomic work is best represented by his many papers on members of the Compositae. Unlike his predecessors and successors, he was not a field botanist and was known to tell persons bringing in a fresh specimen for name, to "press it, dry it, bring it back, and I will name it for you." Weatherby has written of him, "His balancing and restraining influence at a time of considerable, and too often ill-considered, innovation was not the least of his contributions to taxonomy." With other duties, he was also editor for over thirty years of the New England Botanical Club's publication, *Rhodora.*

A colleague of Robinson at Harvard was George Lincoln Goodale (1839–1923), a physician by training, brought to Harvard in 1872 by Gray as instructor in botany, and successor to Gray in 1888 as Fisher Professor of Natural History. Goodale was curator of the Botanical Museum and of the Botanical Garden from 1879–1909 and, more than anyone else, was responsible for the initial development of economic botany at Harvard. Although first a taxonomist, his interests became stronger in morphology and physiology.

Successor to Robinson as director of the Gray Herbarium and to

Goodale as Fisher Professor was Merritt Lyndon Fernald (1873–1950). Born at Orono, Maine, educated there and at Harvard, he became an assistant to Sereno Watson in 1891 and remained at the Gray Herbarium. Fernald was a specialist on the flora and phytogeography of northeastern North America, and, while a majority of his publications were floristic in character, they contained many revisions of difficult genera of that region. His principal monographic work was with the genus Potamogeton, but his complete revision and publication of the eighth edition of *Gray's Manual of Botany* (1950) was his crowning achievement.

The New York School, 1895–

The New York school of taxonomic thought radiated from the accomplishments and personality of Nathaniel Lord Britton. Where the Harvard school reflected a European conservatism, a thoroughness imbued with caution, and a consideration tempered with respect, the New York school, unshackled by any heritage of a past or ties with mentors at other centers, reflected fresh and zestful thinking, recognition of new areas to conquer, and the determination to be a center of aggressive leadership.

Nathaniel Lord Britton (1859–1934), a geologist with a degree in mining engineering from Columbia, was appointed botanist and assistant geologist on the New Jersey Geological Survey. From this introduction to botany and a natural love for plants he became a member and later head of the botany staff at Columbia University, New York. He was the organizer and developer of the New York Botanical Garden, became its first director in 1896, and proved to be a most capable administrator. As a taxonomist he was an ardent and energetic field man. He was author of the *Flora of Bermuda* (1918); coauthor with Addison Brown of *An Illustrated Flora of the Northern States and Canada* (three volumes, 1901); with C. F. Millspaugh of *The Bahama Flora* (1920); and, with J. N. Rose, *The Cactaceae* (four volumes, 1919–23). Britton was a brilliant person, quick thinking, a rapid worker, and possessed of a peppery, volatile disposition. The genera *Brittoniastrum* (Labiatae) by Briquet, and *Brittonella* (Malpighiaceae) by Rusby, commemorate his name.

He attracted students and brought to the botanic garden an assemblage of keen minds, of rugged individualists, and of whom none was a "Harvard school" man. Most of these men accepted the Brittonian ideas of taxonomy. None was noted for taxonomic conservatism, and none of those now deceased could be called a "lumper," while some have been and are considered "splitters." Britton led one school of American thought on matters of nomenclature, wherein he initiated many innovations that were the backbone of the Rochester and American Codes (now superseded), and he and his associates sought unsuccessfully to have them adopted universally. A few of these innovations were ultimately accepted (1930) and incorporated into the international regulations. Britton encouraged his colleagues to "adopt" individually different parts of the country for intensive floristic study and to provide floras and manuals. By this method the ideology of the New York school blanketed a substantial part of the country. The initiation, in 1905, of the serially published *North American Flora,* edited at first by Britton and later by his successors, contributed toward this end. This flora, projected to occupy thirty-four volumes, is yet far from complete. A major portion has been written by Britton and staff members of the New York Botanical Garden. Some of these colleagues of Britton deserve mention for the significance of their taxonomic work.

Per Axel Rydberg (1860–1931) came from Sweden to this country to study mining engineering, but a partially crippling accident in Michigan ended these plans and he became a mathematics teacher in Nebraska. While there he spent his summers as a botanical exporer for the U.S. Department of Agriculture, a work that led to his *Flora of the Sand Hills of Nebraska* (1895). This encouraged him to go to Columbia, where his Ph.D. thesis was *A Monograph of the North American Potentillae* (1898). On completion he became a member of the New York Botanical Garden staff, remaining there until his death. During this thirty-year period he was an herbarium botanist, engaging in little or no field work in the areas of whose plants he published. His important and valued works included much of the *Rosaceae for the North American Flora,* the *Flora of Colorado* (1906), *Flora of the Rocky Mountains* (1917; ed. 2, 1922), and *Flora of the Prairies and Plains* (published posthumously, 1932). Rydberg was extremely liberal in his concepts of genera and species, describing during his lifetime over 100 genera and 1,700 species as new. E. L. Greene sought to commemorate his name by the genus *Rydbergia* (Compositae), but by most authors this genus is now merged in *Actinella.*

Marshall Avery Howe (1867–1936), a Vermonter with his Ph.D. from Columbia in 1898 and a member of the garden staff from 1901 to his death, was a leading mycologist, who carried into cryptogamic botany the Brittonian views applied by other members of the staff to the vascular plants. He succeeded E. D. Merrill as director of the New York Botanical Garden.

John Kunkel Small (1869–1938), whose Ph.D. thesis from Columbia in 1895 resulted in *A Monograph of the North American Species of Polygonum*, contributed significantly to the Britton program of expansion by his lifetime work as a specialist on the flora of southeastern United States. This was an area that Small knew well, especially Florida. His floras included the *Flora of the Southeastern States* (1930; ed. 2, 1913) and the *Manual of Southeastern Flora* (1932).

John Hendley Barnhart (1871–1951) had a medical degree from Columbia but from 1903 to his retirement was a staff member of the Garden, serving variously as editor, librarian, and bibliographer. His proficiency in these fields was of international repute, and he was largely responsible for the early development of the library. Barnhart was a competent taxonomist and the study of the Lentibulariaceae was his specialty. He was an ardent proponent and supporter of Britton's nomenclatural views and defended them at every opportunity, including every international botanical congress from that in Vienna in 1905 to that in Cambridge, England, in 1935.

The exponents of the New York school include also Professor LeRoy Abrams (born 1874) who received his Ph.D. from Columbia in 1910 and soon afterwards became established at Stanford University. Abrams' major contribution, aside from that of teacher, has been *"An Illustrated Flora of the Pacific States, Washington, Oregon and California,"* an incomplete work of which the first three of four volumes have been published.

Other American Taxonomic Centers

Botany in the southeast, after the time of Walter, was best represented by the floristic work of Alvan Wentworth Chapman (1809–1899), a graduate of Amherst, who settled in Georgia and later moved to western Florida. Chapman, a physician, was long a devotee and correspondent of both Torrey and Gray. His *Flora of the Southern States* (1860) went through three editions and reflected his acceptance of Gray's species concepts and was patterned after Gray's Manual. Chapman, color-blind to reds, frequently described pink-flowered species as having white flowers and not a few of his *alba*'s and *albiflora*'s have pink to red flowers. The genus *Chapmannia* of Leguminosae was named in his honor by Torrey and Gray.

The Missouri Botanical Garden, St. Louis, established in 1859 by Henry Shaw, ardent horticulturist and philanthropist, was later endowed by him. It operates in close cooperation with the Henry Shaw School of Botany of Washington University, St. Louis, with members of the scientific staff of the garden serving on the school faculty. The garden has been affiliated with the university since 1899, when William Trelease became its first director. Although never a member of its staff, George Engelmann (1809–1884) long a friend of Henry Shaw, was a dominant and central figure in early St. Louis botanical activity. Engelmann emigrated here from Germany in 1832, and, although a noted physician, he was also an intimate and life-long friend of Asa Gray and an indisputed authority on the taxonomy of the cacti, conifers, gentians, yuccas and agaves, North American grapes, dodders, euphorbias, and evening primroses. Plants of these taxa were sent to him for naming from sponsors and botanists of most North American explorations. His large herbarium of over 100,000 specimens was given by his son to the Missouri Botanical Garden.

William Trelease (1857–1945), a graduate of Cornell and later a student of Farlow (mycology) and Gray at Harvard, was the first Gray professor of botany at the Shaw School. He retired in 1912 to become professor of botany and head of that department at the University of Illinois (1913–26). Trelease, a taxonomist of liberal species concepts, is best known for *The Genus Phoradendron* (1916) and *The American Oaks* (1925). His small book *Winter Botany* (1918) deserves to be better known for its excellent keys to a wide range of woody plants in winter condition. The genus *Treleasia* (Commelinaceae) named in his honor by J. N. Rose is now generally included in *Setcreasia.*

Jesse Moore Greenman (1867–1951), a graduate of the University of Pennsylvania (1893) and of Harvard (1899), was an assistant there to Robinson and a colleague of Fernald. He left Harvard to study under Adolf Engler at the University of Berlin, where he received his Ph.D. degree in 1901. After returning to the Gray Herbarium, where he hoped to remain but was bypassed for promotion in favor of Fernald, he went in 1905 to the Field Columbian Museum of Chicago. He left there for St. Louis in 1913 to become curator of the herbarium under Dr. George T. Moore, also a Harvard man. Greenman was a scholarly man, genteel, quiet, and outstanding as a teacher and developer of taxonomists.

Taxonomically, he was more of a monographer than a floristic specialist, although he did considerable work on Mexican collections in his earlier years. The genus *Senecio* was his special interest, although the Compositae as a whole held much appeal for him. *Greenmania,* named for him, is a genus of the Compositae.

Taxonomy on the Pacific coast centered in California where the early leaders included E. L. Greene and W. L. Jepson. Prior to the entrance of either into California, the first flora of the region was Volney Rattan's *A Popular California Flora* (1879; ed. 2, 1880; ed. 3, 1882). Rattan, a California school teacher and correspondent of Asa Gray, was more of an explorer than botanist.

Edward L. Greene (1893–1915), a native of Rhode Island, educated in Wisconsin and Illinois and ordained an Episcopal minister in Colorado (1873), was active as a taxonomic botanist for half a century. He was a controversial, fearless figure, an egocentric by nature, quarrelsome, and one of America's greatest "splitters" among botanists. Greene was the first professor of botany at the University of California. He was an ardent field man and knew Californian plants better than his predecessors. He was a reformist in nomenclatural matters, antedating Britton and the New York school in his insistence on absolute priority of names and epithets. While in California he published the periodical *Pittonia* (1887–1905), *Flora Franciscana* (1891–97, incomplete), and a *Manual of the Botany of the Region of San Francisco Bay* (1894). In 1885 Greene declared invalid his ordination as an Episcopal clergyman and became a Roman Catholic layman. Ten years later he left California to become professor of botany at the Catholic University of America, Washington, D.C., remaining until 1904 when he went to the Smithsonian Institution. In 1914 he transferred his library and herbarium to Notre Dame University. Greene considered species to be immutable and this philosophy was largely responsible for his having described over 3,000 plants as new species. In early middle-life he feuded openly with Asa Gray, insisting on the right of a botanist to publish his results without first submitting a manuscript or specimen to Gray for approval. Despite this, Gray named the Compositae genus *Greenella* in his honor.

Willis Linn Jepson (1867–1946), a student of Greene, liked to think of himself as the Hooker of California botany; this from his high esteem of Sir Joseph D. Hooker of Kew. Jepson was a conservative taxonomist, a man who knew California flora from field experience, and whose training under E. L. Greene instilled in him the recognition of the importance of knowing plants in their native habitats as well as in the herbarium. Unlike Greene, however, Jepson recognized the importance of populations, accepted the principles of organic evolution, and respected these dicta in arriving at judgments regarding species limits. Jepson was the first Pacific coast botanist to accept the Engler system of classification, but persisted in following the British in adhering to the English system of measurement. His best known publications are probably *A Manual of Flowering Plants of California* (1923–25) and *A Flora of California* (1909–43, incomplete). Jepson never married and was a rugged individualist, who, in his later years, became somewhat anti-social and often difficult to approach. He became a person of very strong likes and dislikes, and often only those persons in his favor had access to his collections and benefit of his counsel. The genus *Jepsonia,* named for him by J. K. Small, is a member of the Saxifragaceae.

The National Herbarium, now at the Smithsonian Institution, Washington, D.C., had its beginnings with collections from various American expeditions and explorations to the far West. Its first botanist was George Vasey (1822–1893), who emigrated as a youth from England to upstate New York. Later he moved to Illinois where he was a practicing physician for many years. Independent means came to him by his second marriage and enabled him to participate in an exploring expedition to Colorado, which led to his becoming Botanist of the U. S. National Herbarium in 1872. Primarily an agrostologist, Vasey published many works on the grasses, among which are *Agricultural Grasses of the United States* (1884) and his *Monograph of the Grasses of the United States and British America* (1892). Successor to Vasey was Frederick Vernon Coville (1867–1937), graduate of Cornell (1887) and botanist on Branner's Geological Survey of Arkansas (1888). Coville was in many ways more of an administrator than a taxonomist, his principal contribution in the latter field being his *Botany of the Death Valley Expedition* (1893). He was important in building up the staff of the National Herbarium and in encouraging and championing taxonomic activity. William R. Maxon (1877–1948) succeeded Coville as head of the National Herbarium; he was a graduate of Syracuse University and after graduation studied under L. M. Underwood (noted authority on American ferns). From 1898 to 1946 Maxon was curator of plants at the U. S. National Museum, where he developed the finest fern herbarium in the country, one which contains about 150,000 specimens. Maxon was a pteridologist who had no interest in nomenclatural squabbles nor in phylogenetic hypothesizing. On several occasions he studied fern types in European herbaria and confined his researches to floristic studies of the ferns and to careful revisions of their local groups. The bibliography of his writings includes over two hundred titles on ferns. The genus *Maxonia* (Polypodiaceae) commemorates his name.

There are many persons who have been omitted from this brief review and, with one exception, those included are not now living. Students desiring to study the subject further should become familiar with the following biographical works by Andrew Denny Rodgers III: *Noble Fellow, William Starling Sullivant* (1940); *American Botany,* 1873–1892 (Asa Gray and contemporaries [1944]); *John Merle Coulter, missionary in science* (1944); *Liberty Hyde Bailey: a story of American Plant Sciences* (1949); *Bernhard Eduard Fernow, a story of North American Forestry* (1951); *Erwin Frink Smith; a story of North American Plant Pathology* (1952).

CHAPTER IX. *Important Families and Their Characters*

AS INDICATED in a previous chapter, the process of plant identification involves placing the "unknown" in successively smaller units of classification. The characteristics of the larger of these units are usually more obvious than those of the smaller. Obviously, it requires little experience to distinguish a fern from a seed-plant, a conifer from a flowering plant, or a lily (a member of the Monocotyledoneae) from a buttercup (a member of the Dicotyledoneae). The person seeking further identification of an "unknown," usually with the aid of a flora or manual, finds it necessary to "key the specimen out" to the family, then to the genus, and ultimately to the species to which it belongs. In most publications, the key to the family is the most difficult to use because the characters of family differentiation often are highly technical, minute in size, or are to be determined only by careful and critical dissection of the reproductive structures. Furthermore, the key to the families represented in a particular flora or manual must be complete and include every family known to be represented in the area treated. Invariably, this means the inclusion of many families that are rare or infrequent, and the more families included the more difficult and complicated the key becomes.

Experience has shown the advantage of being able to recognize on sight the families to which belong the common plants of an area. Knowing the family, one step in the procedure of identification is by-passed. Some families are very easily "spotted," and the amateur and beginner should have little difficulty in knowing the distinguishing characters of about fifty of the families of ferns and seed plants encountered in most parts of the United States and Canada. It is here estimated that fully three-fourths of the plants composing those groups known as spring flowers, wild flowers, and woodland trees are to be found in the families that are treated here briefly. Technical terms are avoided when possible. The effort is made to focus attention on the principal distinguishing characters and on the special terminology common to members of these families.

The morphology and terminology peculiar to the ferns have been treated in Chapter IV (p. 27). By conservative concepts, most of our native terrestrial ferns belong to the Polypodiaceae. These ferns, for the most part, are clump-forming plants or produce creeping rhizomes or stolons, and their leaves seemingly arise from the ground. Other families discussed previously include the Selaginellaceae (Fig. 5) to which belong the club-mosses and lycopodiums, the Isoetaceae (Fig. 6) known also as quillworts, and the aquatic floating ferns of the Salviniaceae (Fig. 7). In addition, there are the Marsileaceae or water-clovers, which grow in shallow water and have leaves of four leaflets that resemble those of oxalis or a four-leaf clover; here the sporangia are in sori that are contained within a hard pea-shaped sporocarp situated near the base of the leaf petiole. The filmy-fern family, Schizaeaceae, produce pear-shaped sporangia with an apical annulus (Fig. 8). In the Osmundaceae, to which belong the Cinnamon, Royal, and Interrupted ferns, the sporangium do not have the incomplete annulus characteristic of the Polypodiaceae (Fig. 18 f) but has a small lateral annulus not readily apparent when examined with a hand lens (Fig. 18 i).

The gymnosperms, like the ferns, were accounted for in Chapter IV (p. 31) and are not treated here. The principal families of North America and their characteristics are to be sought in the previous account, and for further details see Lawrence *Taxonomy of Vascular Plants* (pp. 355–370). The pages that follow provide brief synopses of the distinguishing characters of the more important families of Angiospermae, the flowering plants. These are composed of two subclasses, the Monocotyledoneae and the Dicotyledoneae.

THE MONOCOTYLEDONEAE

For brevity the members of this group often are termed monocots and those of the Dicotyledoneae, dicots. The monocots are not distinguished by any single character but the following characters in combination, with certain exceptions, serve to characterize the group:

Stems with vascular strands scattered through a large pith;
Rootstocks often rhizomatous, bulbous, or cormous;
Leaves with parallel venation; and
Flowers three-merous.

The more dominant families include the following:

Cyperaceae	Gramineae	Iridaceae
Araceae	Liliaceae	Orchidaceae
	Amaryllidaceae	

The Gramineae—Grass Family (Fig. 44)

Grass stems are often called *culms,* and are jointed at the nodes. The leaves are arranged in a ½ phyllotaxy and are composed of three parts, the sheath, a ligule (Fig. 44 c) and a blade. The flowers are tiny, much

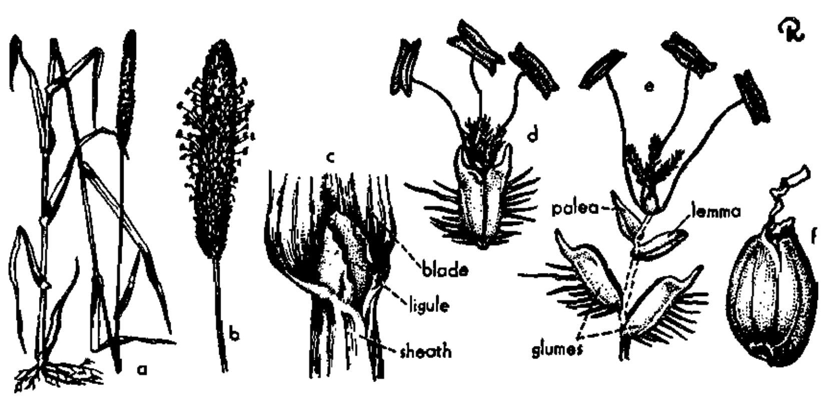

Fig. 44. Gramineae. *Phleum pratense:* a, habit of plant (culms bent); b, spicate inflorescence; c, nodular portion of leaf, showing ligule; d, spikelet; e, same, "exploded" to show orientation of organs; f, fruit containing seed.

reduced by loss of the perianth (no petals or sepals are present), and are much congested into *spikelets* (Fig. 44 d). The grass flower is often termed a *floret.* The floret may be bisexual or unisexual, and typically it is composed of three stamens (six in rice and most bamboos) and a superior one-celled ovary with a single ovule, terminated by two plumose styles or style-branches. The spikelet may contain one to many florets. Usually the florets are so short-stalked as to appear sessile. In a one-flowered spikelet (see Fig. 44 e) there are two dry bracts called *glumes.* Above these, and often of thinner texture and enveloping the floret, are two more bracts, the lower is the *lemma* and the upper the *palea*. In Fig. 44 e the relative position of these is shown in an expanded (or exploded) diagram, the dotted lines show the axis as if elongated. Actually, it is very short and the spikelet is much condensed as in Fig. 44 d. The fruit is a modified achene, termed a *caryopsis* and differing from an achene in the coat being loose from the seed.

Cyperaceae—Sedge Family

Vegetatively this family is distinguished from the grasses in the stems usually solid and triangular in cross-section, the leaves arranged in a ⅓ phyllotaxy, and in the absence (usually) of any ligule. The flowers are bisexual or unisexual and arranged in spikelets that are much more simple than the grass spikelet for here the flower is subtended by one or two chaffy bracts, not differentiated into glumes, lemma, and palea as in grasses. A perianth represented by bristles or scales is frequently present. The fruit is an achene. In the large genus *Carex*, the ovary is enclosed in a thin sac termed a *perigynium* which persists in fruit.

Araceae—Arum Family (Fig. 45)

Members of this family are commonly referred to as aroids. The family is primarily tropical, but its range extends northward to the

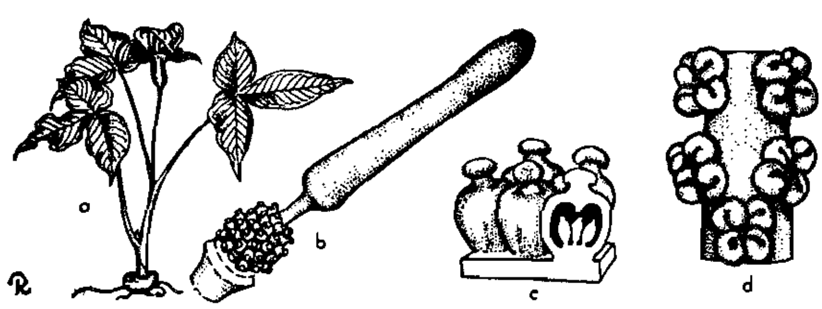

Fig. 45. Araceae. *Arisaema triphyllum:* a, plant in flower; b, pistillate spadix; pistillate flowers; d, staminate flowers (staminate spadix from another plant not shown).

arctic. The leaf venation may be reticulate, pinnate, or parallel. Vegetative portions often contain bundles of crystals of calcium oxalate (raphides) that impart a pungent "flavor" and may be highly irritating to the mouth if eaten uncooked. Members of the family are best distinguished by the spike-like inflorescence, termed a *spadix*, that is subtended or enveloped by a fleshy or herbaceous *spathe* (Fig. 56 a). The spadix may be fertile throughout or the flowers restricted to the basal portion and the distal part is then sterile (Fig. 45 b). The flowers may be bisexual or unisexual, with or without a perianth of four to six minute scale-like tepals not differentiated into petals or sepals. The ovary is superior, one- to many-loculed, and the placentation basal, parietal, axile, or pendulous. The stigma is usually capitate. The fruit is a berry.

Liliaceae—Lily Family (Fig. 46)

The leaves are mostly parallel-veined, the flowers typically are of six tepals, six stamens, and a single tricarpellate pistil whose ovary is usually superior, three-loculed, with axile placentation (Fig. 46 b, c). The stigma is generally three-lobed or branched (Fig. 46 d) and a style

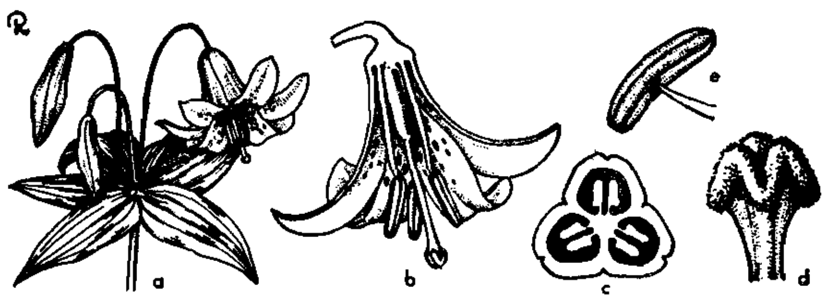

Fig. 46. LILIACEAE. *Lilium canadense:* a, inflorescence; b, flower, vertical section; c, ovary, cross-section; d, stigmas, each bilobed; e, versatile anther (appearing as if basifixed in b, before anthesis).

is usually present. The inflorescence type is variable and not diagnostic. The fruit may be a berry or a capsule. In most members of the family an underground scaly bulb is present.

Amaryllidaceae—Amaryllis Family (Fig. 47)

Opinion is divided on the bases for distinguishing this family from the Liliaceae. By older views, *and followed in most contemporary floras,* those plants whose flowers produced a superior ovary were placed in the Liliaceae, and those with an inferior ovary were placed in the Amaryllidaceae. The number of genera representing intermediates between these two situations invalidate the distinction.

More recently, data from studies of morphology, anatomy, embryology, and karyology have supported the view that a better criterion for distinction of Amaryllidaceae from Liliaceae is provided by the inflorescence. By this view, those genera whose inflorescence is an umbel subtended by one or more papery spathes or bracts are placed in the

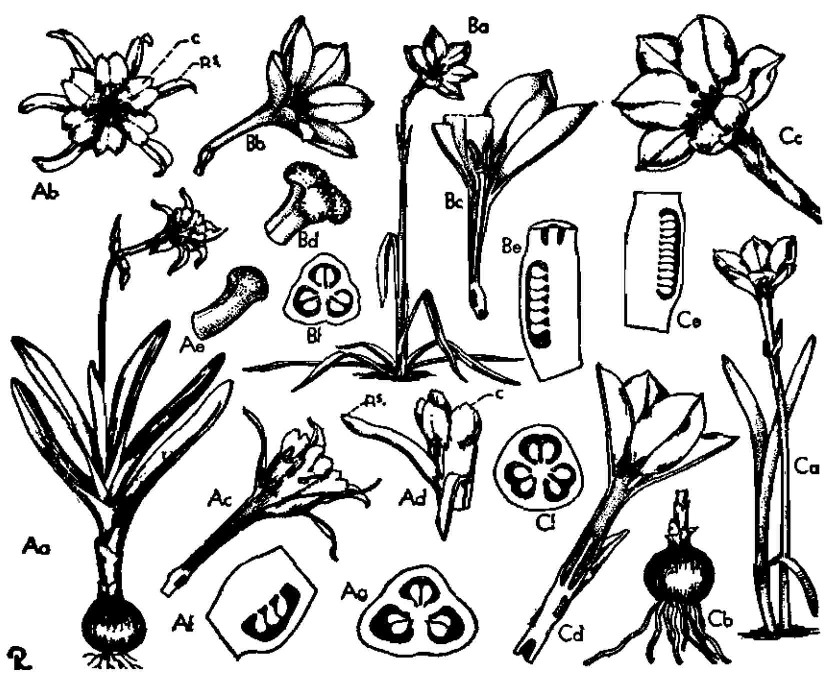

Fig. 47. AMARYLLIDACEAE. A, *Hymenocallis narcissiflora:* Aa, plant in flower, *with bulb; Ab, flower, face view; Ac, same, vertical section; Ad, perianth section,* showing corona; Ae, style tip, with three-lobed stigma; Af, ovary, vertical section; Ag, ovary, cross-section. B, *Zephyranthes grandiflora:* Ba, plant in flower, less bulb; Bb, flower, habit; Bc, same, vertical section; Bd, style tip and stigma; Be, ovary, vertical section; Bf, ovary, cross-section. C, *Cooperia pedunculata:* Ca, plant in flower; Cb, bulb; Cc, flower, habit, with spathe valve; Cd, same, vertical section; Ce, ovary, cross-section. (c, corona; p.s., perianth segment.)

Amaryllidaceae. This results in the transfer to this family from the Liliaceae of some genera with a superior ovary, as *Allium, Agapanthus,* and *Brodiaea.* In using this criterion for separation, it must be remembered that in advanced situations the umbel may be reduced to a single flower (as in some species of *Narcissus*), but even so, that amaryllidaceous flower is subtended by one or more papery spathe-like bracts. As in Liliaceae, the stamens are six in number.

In some members of the family a *corona* may be present. This may be a part of the perianth (Fig. 42 Ad), such as the cup of Narcissus, or it may be a thin tissue connecting the stamen filaments.

Iridaceae—Iris Family (Fig. 48)

This is a distinctive family, whose members have flowers with a trilocular inferior ovary with axile placentation, and three stamens. The rootstock is more commonly rhizomatous than in the lily or amaryllis

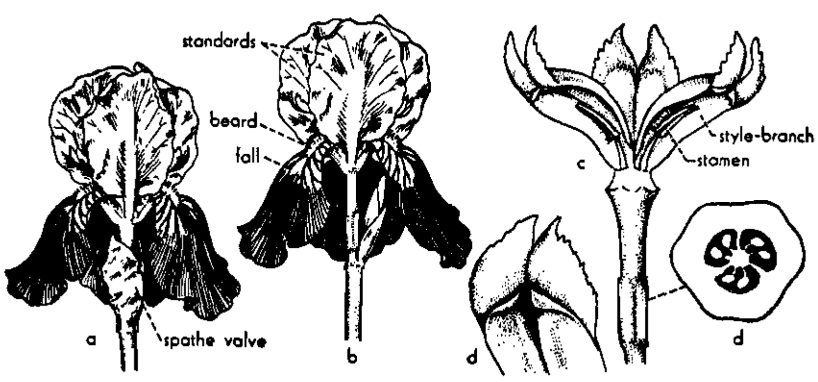

Fig. 48. IRIDACEAE. *Iris germanica:* a, flower with subtending spathe-valves; b, same, spathe-valves removed; c, same, less perianth; d, style-branch and stigma; e, ovary cross section.

family, although bulbous and cormous members occur. In the iris tribe the style branches are winged and petaloid (Fig. 48 c), and each of the three stigmas is reduced to a transverse line on the lower (dorsal) side (Fig. 48 d).

Orchidaceae—Orchid Family (Fig. 49)

This is a distinctive and highly complex family of monocots that is characterized by the flowers zygomorphic, the perianth in two series with the outer composed of two to three green sepals and the inner of three petals, one of which is enlarged and highly modified into a segment termed a *labellum* (Fig. 49 Ac). The ovary is inferior, usually resupinate (twisted 180°, as in Fig. 49 Bb), one- to three-loculed with parietal or axile placentation, and the ovules abundant but exceedingly minute. Two subfamilies are present: Diandrae (Fig. 49 A) and Monandrae (Fig. 49 B). In each the androecium and style and stigmas are fused to form a *column* or *gynandrium*. In the Diandrae, there are two functional sessile anthers (Fig. 49 Af) producing granular tetrads of pollen, and a third nonfunctional anther consists of a conspicuous glandular staminode (Fig. 49 AF, Ag). In this subfamily there are three stigma lobes, situated beneath the staminode. In the Monandrae,

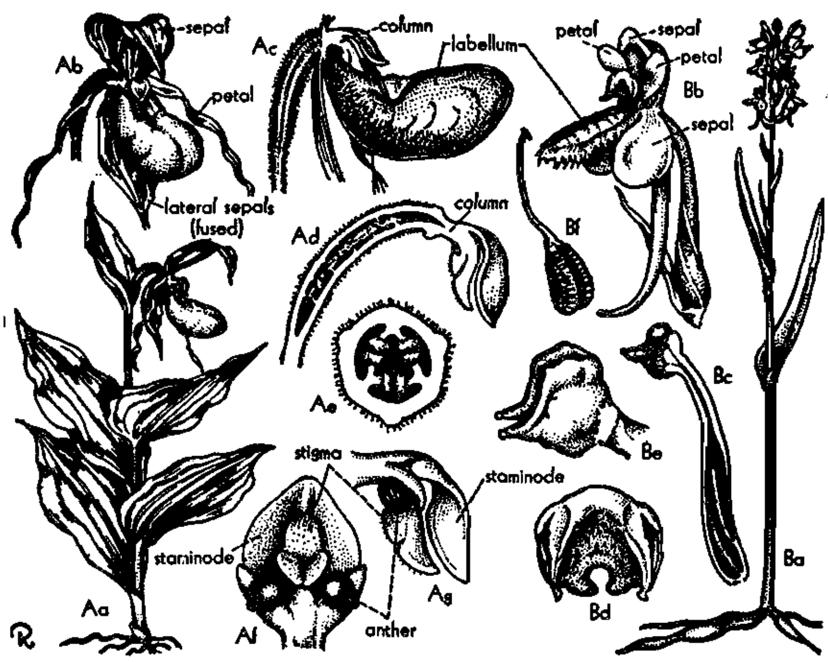

Fig. 49. Orchidaceae. A, *Cypripedium Calceolus:* Aa, plant in flower; Ab, flower, habit; Ac, same, vertical section; Ad, gynandrium, vertical section; Ae, ovary, cross section; Af, column, viewed from below; Ag, same, side view. B, *Habenaria:* Ba, plant in flower; Bb, flower, habit; Bc, gynandrium, vertical section; Bd, column, viewed from below; Be, same, side view; Bf, pollinium.

there is a single terminal anther, whose pollen grains are in tetrads that are generally agglutinated into firm to bony bodies termed *pollinia* (Fig. 49 Bf). These pollinia are generally attached to the apical ends of the anther sac by slender stalks called *caudicles.* The number of pollinia in an anther may be two, four, or eight depending on the genus. In this subfamily the stigma is situated in a usually depressed cavity below and in back of the anther. For a more detailed discussion of the floral morphology, see Lawrence, *Taxonomy of Vascular Plants,* pp. 433–437.

Dicotyledoneae

The dicots may be distinguished from the monocots by the combination of the following characters, recognizing that exceptions may occur in one or some of those cited:

1. Stem with a true cambium cylinder, the pith usually small and no vascular strands scattered through it;
2. Roots usually fibrous; no scaly bulbs produced;
3. Leaves mostly pinnately or palmately veined; and
4. Flowers not commonly three-merous throughout, although the pistil is not infrequently tricarpellate.

The catkin-producing families are characterized by the flowers of one or both sexes in flexuous aments or catkins. Here are included the (mostly) unrelated families Salicaceae, Juglandaceae, Betulaceae, and Fagaceae.

Salicaceae—Willow Family

The willows are dioecious trees or shrubs with the flowers of both sexes in flexuous catkins. Each flower is subtended by a finger- or cup-like gland, the ovary is superior, two-carpelled, unilocular, and the placentation is parietal. The stigmas are two in number, and each may be lobed or fringed. The fruit is a capsule. The seeds are comose.

Juglandaceae—Walnut or Hickory Family

This is a family of monoecious trees or shrubs with pinnately compound leaves, the staminate flowers in catkins, but the pistillate flowers often not so. The stamens are three to one hundred in number, with erect basifixed anthers. The ovary is inferior, mostly two-carpelled, and contains a solitary ovule. The styles are usually two. The fruit is a dehiscent or indehiscent drupe-like nut.

Betulaceae (Corylaceae)—Birch Family (Fig. 50)

These are monoecious trees or shrubs with simple leaves. The staminate flowers, and frequently the pistillate, are in catkins. The flowers are in much condensed cymules, with one to three bracts (sometimes fused and then seemingly three-lobed). The staminate flowers contain many stamens. The pistillate flower has an inferior or nude (position not then identifiable) ovary, subtended by one large and two small bracts, which is two-loculed and two-carpelled with basal placentation. The style is one or two. The fruit is a small nut or short-winged samara.

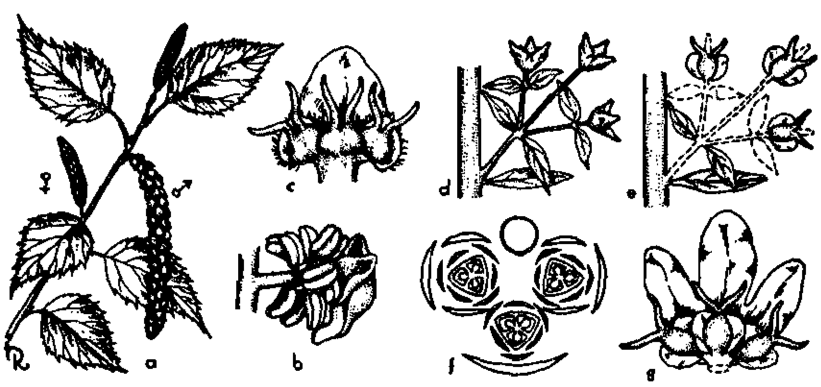

Fig. 50. BETULACEAE. *Betula pendula:* a, flowering branch; b, staminate flowers; c, pistillate flowers; d, schematic diagram of theoretical three-flowered pistillate cymule believed ancestral to modern types; e, schematic diagram of pistillate cymule of *Betula Medewiewii;* f, "floral" diagrams of inflorescence of hypothetical cymule shown in "d"; g, pistillate cymule, *B. Medewiewii.* (d-g redrawn from Abbe, *1935.*)

Fagaceae—Beech Family

A family of mostly monoecious trees and shrubs, the beech's staminate flowers are usually in pendulous catkins, and the pistillate ones are solitary or clustered. The pistillate flower is mostly within an involucre of generally many adnate and imbricated bracteoles. The ovary is inferior, three- to six-loculed and carpelled, the placentation axile, and the styles as many as the locules. The perianth is composed of four to six tepals. The fruit is a one-seeded nut, subtended or enveloped by a cupule or involucre (sometimes two to five within the involucre).

A group of unilocular one-ovuled families mostly lacking a showy perianth is composed of the Polygonaceae, Chenopodiaceae, and Amaranthaceae.

Polygonaceae—Buckwheat Family

The stems usually have swollen nodes and the leaves are subtended by a sheathing stipular growth called the *ochrea* (absent in the tribe Eriogoneae, in which the flowers are in involucrate heads or umbels). The flowers are usually bisexual with perianth of three to six distinct tepals in two whorls, with six to nine stamens and a superior compressed or three-angled ovary which is unilocular with a basal ovule and is terminated by two to four stigmas. The fruit is an achene whose seed has a curved or ç-shaped embryo.

Chenopodiaceae—Goosefoot Family (Fig. 51)

This is a family of mostly salt-loving plants with often fleshy or granularly farinose herbage (i.e., herbaceous vegetative parts). The flowers are mostly bisexual with a perianth of two to five connate sepals

Fig. 51. CHENOPODIACEAE. *Beta vulgaris:* a, garden beet, foliage and root; b, flowering stem; c, flower; d, same, vertical section; e, anther, dorsal side; f, fruit; g, same, vertical section; h, seed. (c-e after LeMaout and Decaisne.) (From L. H. Bailey, *Manual of cultivated plants,* The Macmillan Company, 1949. Copyright 1924 and 1949 by Liberty H. Bailey.)

that usually persist in fruit. No petals are present. The stamens are as many as the sepals and opposite them. The ovary is mostly superior and two- to three-carpelled. The fruit is a nutlet, whose seed contains a coiled or peripheral embryo.

Amaranthaceae—Amaranth Family (Fig. 52)

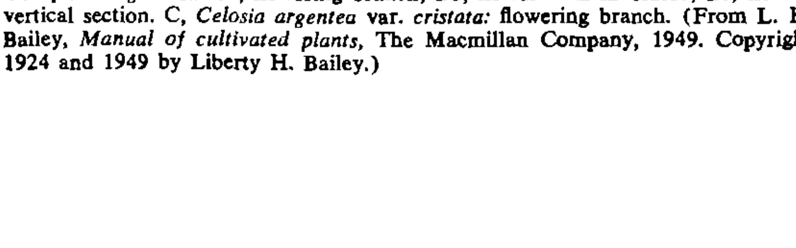

Fig. 52. AMARANTHACEAE. A, *Amaranthus caudatus:* flowering branch. B, *Gomphrena globosa:* ba, flowering branch; Bb, flower with involucre; Bc, flower, vertical section. C, *Celosia argentea* var. *cristata:* flowering branch. (From L. H. Bailey, *Manual of cultivated plants,* The Macmillan Company, 1949. Copyright 1924 and 1949 by Liberty H. Bailey.)

The herbage is not fleshy nor farinose, but often is red-pigmented in part. The flowers are bisexual, and are subtended by a membranous or scarious persistent bract and two similar bractlets. The perianth consists of three to five scarious sepals. The stamens are generally five in number and the filaments are basally to wholly connate. The ovary is superior, two- to three-carpelled, and one-loculed. The fruit is a nutlet, or rarely a circumscissile capsule.

For the most part this next group of families have a showy polypetalous corolla (the petals falling one by one).

Caryophyllaceae—Pink Family (Fig. 53)

This is a family of herbs that is characterized by the leaves opposite, often linear and parallel-veined, and the nodes swollen. The flowers have a superior, unilocular, three- to five-carpelled ovary whose placentation is free-central (rarely basally trilocular with axile placentation). The fruit is a capsule.

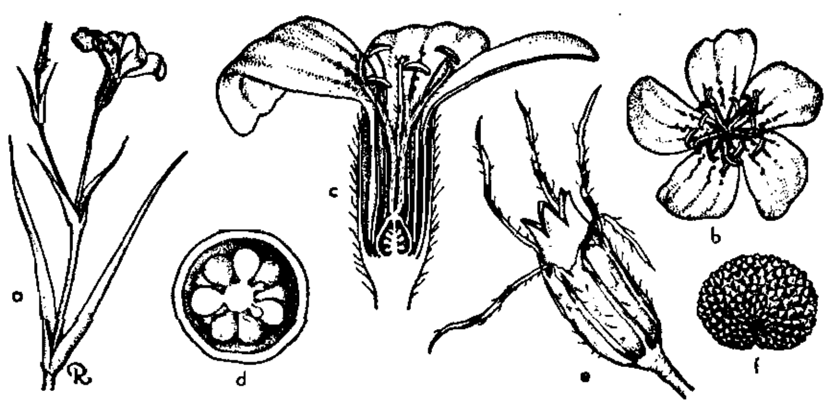

Fig. 53. Caryophyllaceae. *Agrostemma Githago:* a, flowering branch; b, flower, face view; c, same, vertical section; d, ovary, cross-section; e, capsule with persistent calyx; f, seed.

Ranunculaceae—Buttercup Family (Fig. 54)

These are mostly herbaceous plants, often with acrid sap, but which are characterized by the stamens many and spirally arranged, and the gynoecium of three to many spirally arranged pistils. Each pistil consists of a one-loculed, one-carpelled, superior ovary with marginal (parietal) placentation (Fig. 65 d). The fruit is typically a follicle, but may be an achene, berry, or capsule.

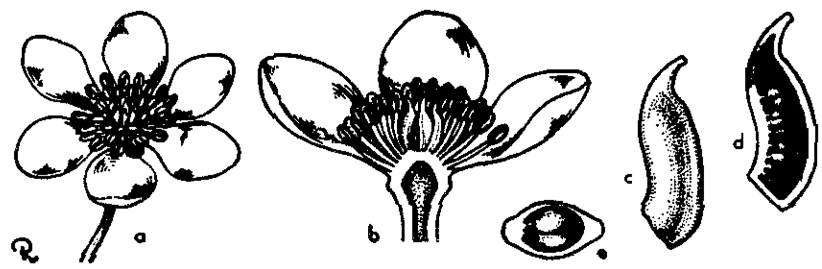

Fig. 54. RANUNCULACEAE. *Ranunculus* sp.: a, flower; b, same, vertical section; c, pistil; d, same, vertical section; e, same, cross-section.

Papaveraceae—Poppy Family

These are mostly herbs, often with milky latex or colored sap, characterized by a calyx that usually falls when the flower opens, and petals that generally appear crumpled on opening. The stamens are usually many, in several whorls. The pistil is solitary, with a superior, unilocular, multicarpellate ovary whose placentation is parietal. The style is short or absent and the stigma is radiate or lobed. The fruit is usually a capsule dehiscing by apical pores or by valves.

Cruciferae—Mustard Family (Fig. 55)

These are herbaceous plants, often with stellate hairs, whose flowers have four distinct sepals and four petals (Fig. 55 a). The stamens are six and are termed *tetradynamous*, because one pair is longer than the other two pairs (Fig. 55 c). There is a single pistil whose ovary is superior, two-loculed, four-carpelled, and has parietal placentation (Fig. 55 e). The styles are short or absent and the stigmas two. The fruit is a modified capsule, usually dehiscing by two lateral valves (having a central septum) and when long and slender is termed a silique (Fig. 55 j), or when short and squat is termed a silicle (Fig. 55 k). The arrangement of cotyledons and radicle within the seed provide characters of taxonomic importance. The cotyledons may be acumbent (Fig. 55 i), incumbent (Fig. 55 k), conduplicate (Fig. 55 n), or double-acumbent (Fig. 55 q).

Crassulaceae—Orpine Family

These are herbs or shrubs, with succulent leaves that often are in rosettes when young. The flowers are distinctive because the sepals, petals, stamens, and pistils are of the same number (usually four or five), or the stamens are twice as many as the components of other whorls. Each pistil usually has a conspicuous gland at base and on the adaxial side. The ovaries are superior, unilocular, unicarpellate, with marginal (parietal) placentation, style and stigma one. The fruit is a follicle.

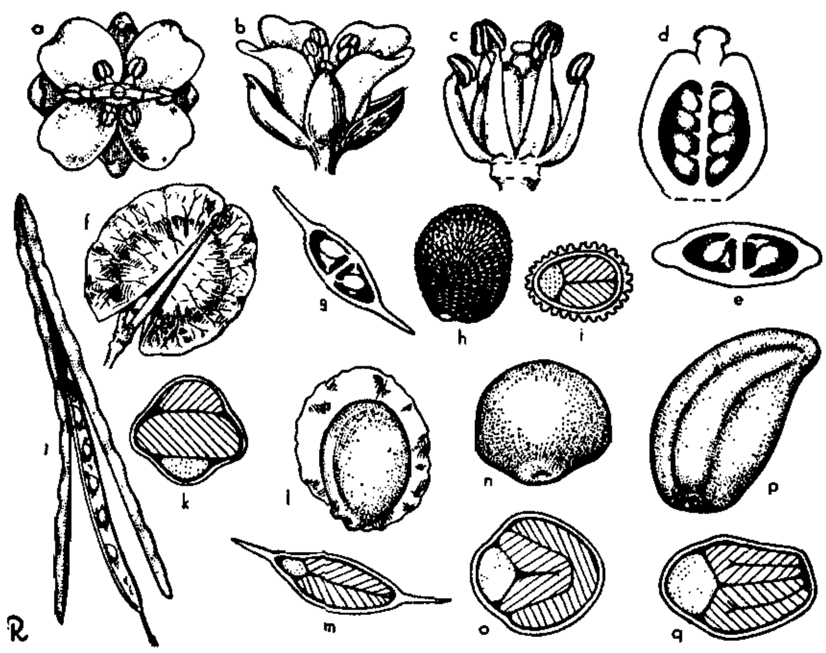

Fig. 55. CRUCIFERAE. *Thlaspi arvense:* a, flower, face view; b, same, side view; c, same, perianth removed; d, ovary, vertical section; e, same, cross-section; f, silicle, side view; g, same, cross-section; h, seed; i, same, cross-section. *Hesperis matronalis:* j, silique, dehiscing; k, seed, cross-section. *Alyssum saxatile:* l, winged seed; m, same, cross-section. *Brassica arvensis:* n, seed; o, same, cross-section. *Cakile maritima:* p, seed; q, same, cross-section. (Redrawn from L. H. Bailey, *Manual of cultivated plants,* The Macmillan Company, 1949.)

Saxifragaceae—Saxifrage Family

As conservatively defined in most floras, this is a difficult family to distinguish. There is no single field character by which it can be separated from some members of the Rosaceae. It differs from that family in the more abundant endosperm of the seeds, and in its estipulate or rarely stipulate leaves. From the Crassulaceae, it differs in the pistils (when two or more) not subtended by a gland.

Rosaceae—Rose Family (Fig. 56)

This is a large and diverse family whose members have leaves that are usually stipulate. Its bisexual flowers are of one of three types: (1)

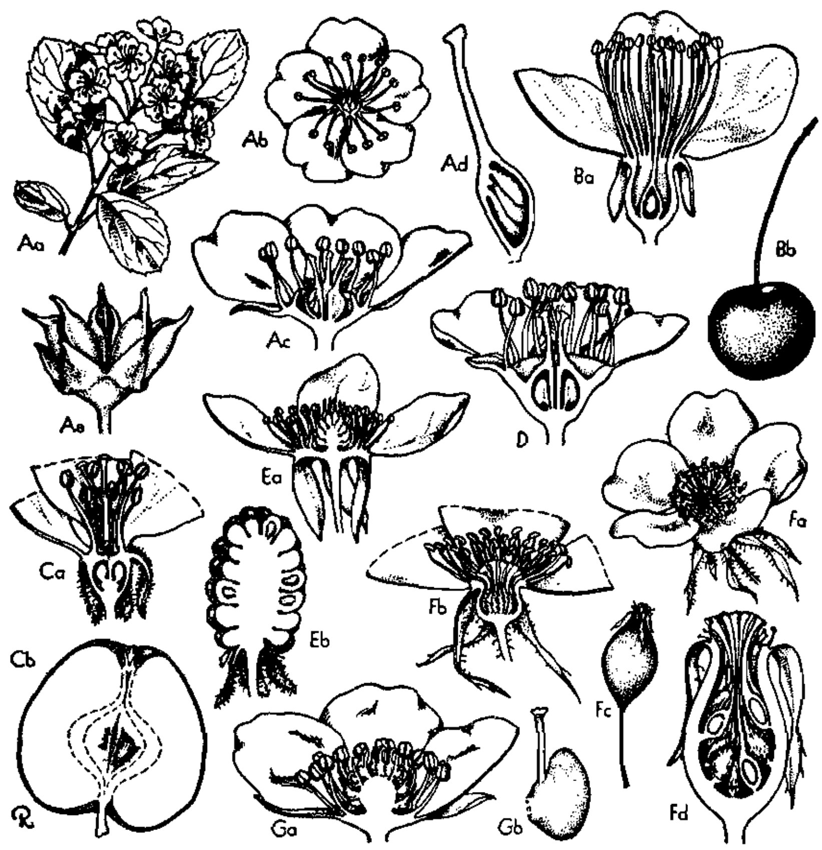

Fig. 56. ROSACEAE. A, *Spiraea Vanhouttei:* Aa, flowering branch; Ab, flower, face view; Ac, same, vertical section; Ad, single pistil, vertical section; Ae, cluster of follicles. B, *Prunus* sp.: Ba, flower, vertical section; Bb, fruit. C, *Malus sylvestris:* Ca, flower, vertical section; Cb, fruit, vertical section. D, *Cotoneaster horizontalis:* D, flower, vertical section. E, *Rubus occidentalis:* Ea, flower, vertical section; Eb, fruit, vertical section. F, *Rosa canina:* Fa, flower, face view; Fb, same, vertical section; Fc, hip; Fd, same, vertical section showing achenes within. G, *Fragaria chiloense:* Ga, flower, vertical section; Gb, accessory fruit, vertical section; Gc, achene. (Redrawn from L. H. Bailey, *Manual of cultivated plants,* The Macmillan Company, 1949.)

the gynoecium of few to many pistils, partially to completely enclosed in a hypanthium and whose ovaries are superior, unilocular, unicarpellate, and uniovulate, and the stamens several whorls; (2) the gynoecium of a single pistil whose ovary is inferior, multicarpellate, multilocular, with axile placentation and many ovules; and (3) the gynoecium of a single pistil situated in a hypanthium, the ovary superior, multicarpellate, unilocular with a single parietal ovule. In the first type the fruit is usually an achene or follicle; in the second a pome; and in the third a drupe.

Leguminosae—Pea Family (Fig. 57)

The family is composed of three subfamilies as distinguished below, but bonded together by a common type of fruit, the legume, a dry dehiscent fruit that is the product of a simple ovary and which differs from a follicle in dehiscing by two sutures instead of by one (Fig. 57). In some members of the family the fruit is a loment, a modified legume which dehisces by transverse joints (Fig. 40 i). In each subfamily the ovary is superior, unilocular, unicarpellate, and its few to several ovules are arranged in a marginal (parietal) placentation type.

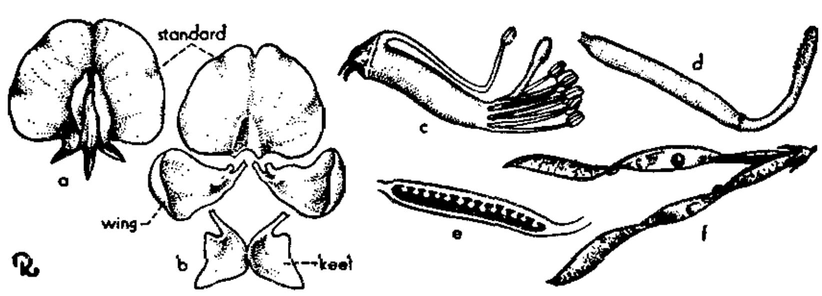

Fig. 57. LEGUMINOSAE. *Lathyrus latifolius:* a, flower, face view; b, corolla; c, flower, less perianth; d, pistil; e, ovary, vertical section; f, legume, dehisced.

Mimosoideae: flowers actinomorphic, the calyx and corolla valvate in bud.
Caesalpinioideae: corollas zygomorphic, the posterior petal innermost, the petals five and distinct.
Lotoideae: the corolla zygomorphic and of the papilionaceous type (Fig. 57), consisting of a standard (the outermost petal), two wing petals, and two keel petals that are basally connate; the stamens are five to ten in number and are usually diadelphous (Fig. 57 c) or monadelphous (Fig. 32 d, e, f).

Euphorbiaceae—Spurge Family (Fig. 58)

This is a family of monoecious or dioecious plants, often with milky juice. The staminate flowers usually have the stamens as many or twice as many as petals (or reduced to a single stamen in *Euphorbia* [Fig. 58 d]). The pistillate flowers have a single pistil whose ovary is superior, mostly three-loculed and three-carpelled with axile placentation and one to three ovules in each locule (Fig. 58 e, f). There are generally three simple or bilobed styles. The fruit is usually a capsule. (In *Euphorbia* the perianth is missing or reduced to bristles.)

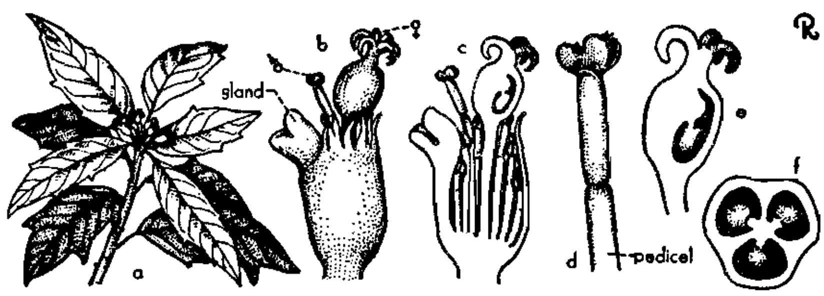

Fig. 58. Euphorbiaceae. _ *horbia:* a, flowering branch; b, cyathium of staminate and pistillate flowers; c, same, vertical section; d, staminate flower; e, pistillate flower; f, ovary, cross-section.

Malvaceae—Mallow Family (Fig. 59)

The sap often is viscid or mucilaginous. The flowers are generally bisexual, actinomorphic, and have a calyx of five sepals and a corolla of five petals. Often an involucre of bracts subtends the calyx. The stamens are numerous and monadelphous, with one-celled anthers. The gynoecium is usually composed of a single pistil having a superior two- to many-loculed and carpelled ovary and axile placentation (Fig. 59 Bc). Sometimes the carpels are represented by separate pistils (Fig. 59 Cb).

Violaceae—Violet Family

The flowers are bisexual and usually zygomorphic, with a calyx of five sepals and corolla of five petals (the lowermost often spurred). The five stamens are connivent about the pistil and the two lower are often spurred. There is a single pistil, with the ovary superior, one-loculed, three to five-carpelled, and the many ovules are arranged in a parietal type of placentation (Fig. 35 b).

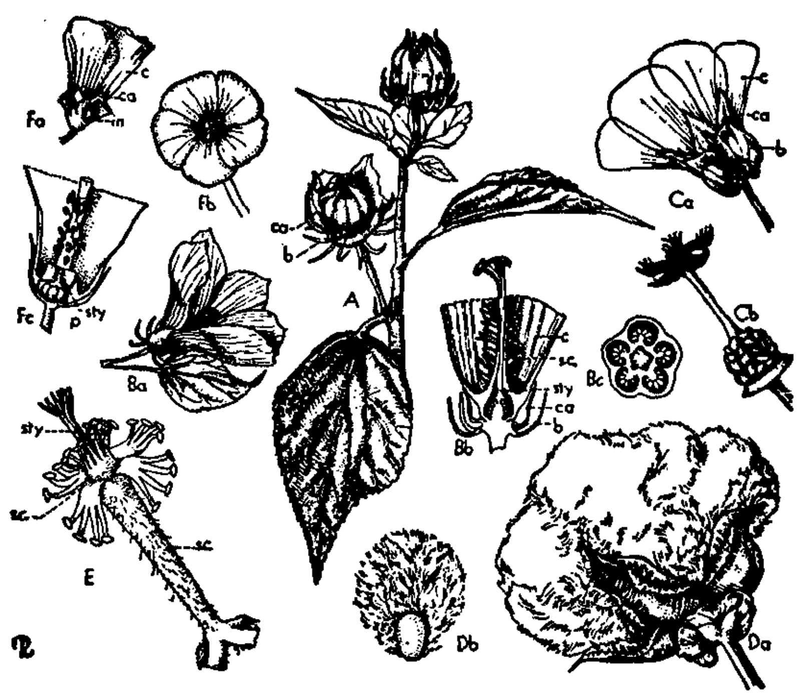

Fig. 59. MALVACEAE. A, *Hibiscus palustris:* fruiting branch. B, *Hibiscus Moscheutos:* Ba, flower; Bb, same, vertical section, perianth partially excised; Bc, ovary, cross-section. C. *Malope trifida:* Ca, flower; Cb, same, gynoecium. D, *Gossypium hirsutum:* Da, boll; Db, seed. E, *Sidalcea candida*, style enveloped by double staminal tube. F, *Anoda cristata:* Fa, flower, side view; Fb, same, face view; Fc, partial vertical section. (b, bract; c, corolla; ca, calyx; in, involucre; p, pistil; s.c., staminal column; sty, style.) (From L. H. Bailey, *Manual of cultivated plants*, The Macmillan Company, 1949. Copyright 1924 and 1949 by Liberty H. Bailey.)

Cactaceae—Cactus Family (Fig. 60)

The plants are mostly succulents, with enlarged fleshy stems, producing small, often caducous, leaves, and spines (Fig. 60 a). The flowers are mostly bisexual and actinomorphic, with the perianth only weakly differentiated into sepals and petals and fused basally into an hypanthium. There is a single pistil, with a usually inferior unilocular, three-to many-carpelled ovary containing many ovules in a parietal type of placentation (Fig. 60 b). There is a single style terminated by as many branches and stigmas as there are carpels. The stamens are very numerous, arising spirally or in clusters, and with two-celled anthers. The fruit is a berry.

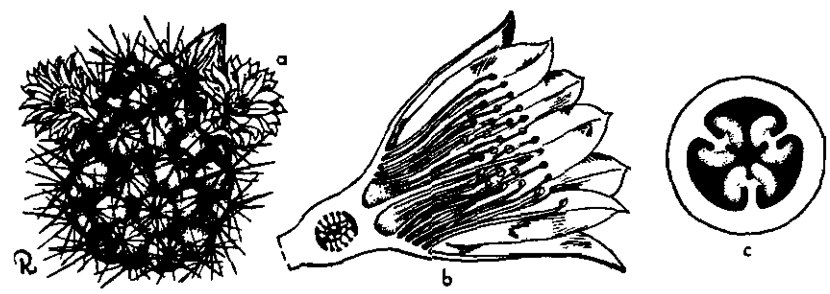

Fig. 60. CACTACEAE. *Mammillaria:* a, plant in flower; b, flower, vertical section; c, ovary, cross-section.

Onagraceae—Evening-primrose Family (Fig. 61)

This family is characterized by the flowers having typically the parts in multiples of two or four, a single pistil whose ovary is inferior and multiovulate, with axile placentation, and terminated by an hypanthium from whose rim emerge the sepals, petals, and stamens.

Fig. 61. ONAGRACEAE. *Oenothera:* a, plant in flower; b, flower; c, same, vertical section; d, ovary, vertical section; e, ovary, cross-section.

Umbelliferae—Carrot Family (Fig. 62)

The umbellifers are a family composed mostly of herbs, distinguished by the presence of aromatic oils, the usually sheathing leaf bases (petioles), and the typically umbellate inflorescence. In most members, the inflorescence is a *compound umbel* (Fig. 62 a) composed of primary peduncles or stalks termed *primary rays* that bear diminutive umbels termed *umbellets* (Fig. 62 b). The flowers of the umbellet are borne on pedicels termed *secondary rays*. The umbel and the umbellet

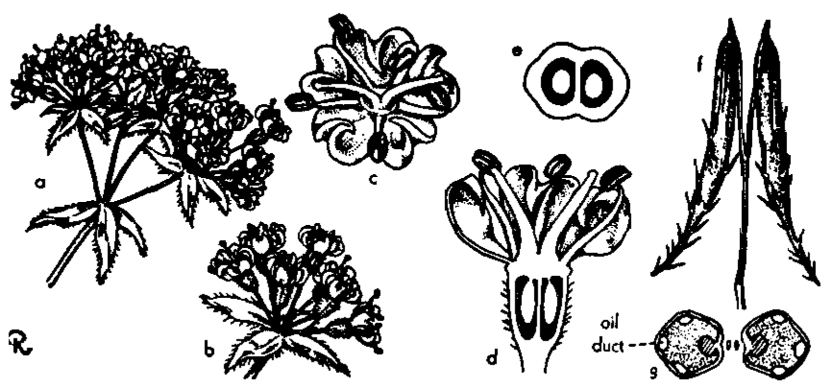

Fig. 62. UMBELLIFERAE: a, umbel; b, umbellet; c, flower, face view; d, same vertical section; e, ovary, cross-section; f, schizocarp; g, same, cross-section.

may be subtended by an involucre of bracts and an involucel of bractlets respectively. The flower has a five-merous perianth of calyx and corolla with the calyx often caducous. The stamens are five in number. The ovary is inferior, two-locular and carpelled, each locule with a single pendulous ovule (Fig. 62 d). The styles and stigmas are two. The fruit, a *schizocarp*, is distinctive for the family. It usually dehisces into two equal mericarps, each borne on a wiry carpophore (Fig. 62 f). The adjoining faces of a pair of mericarps are termed *commissural* faces (or surfaces). The mericarp is often 3-5-7-ribbed and the oil ducts situated just beneath or between the ribs provide diagnostic characters.

Families with gamopetalous corollas include the following:

Ericaceae—Heath Family

This is a family of mostly woody plants, often with persistent leaves. The flowers have a four- to seven-lobed calyx and corolla, with the stamens mostly twice as many as corolla-lobes and arising from a glandular disk. The anthers often have caudal appendages, and dehisce by apical pores. The ovary may be superior or inferior. It is typically four- to seven-loculed and carpelled, with axile placentation.

Primulaceae—Primula Family (Fig. 63)

This family of herbaceous plants is similar in some respects to the Carophyllaceae, especially in its superior ovary with free-central placentation, but differs in the gamopetalous corolla and in the stamens borne on the corolla-tube and opposite the corolla-lobes. The fruit is a many-seeded capsule.

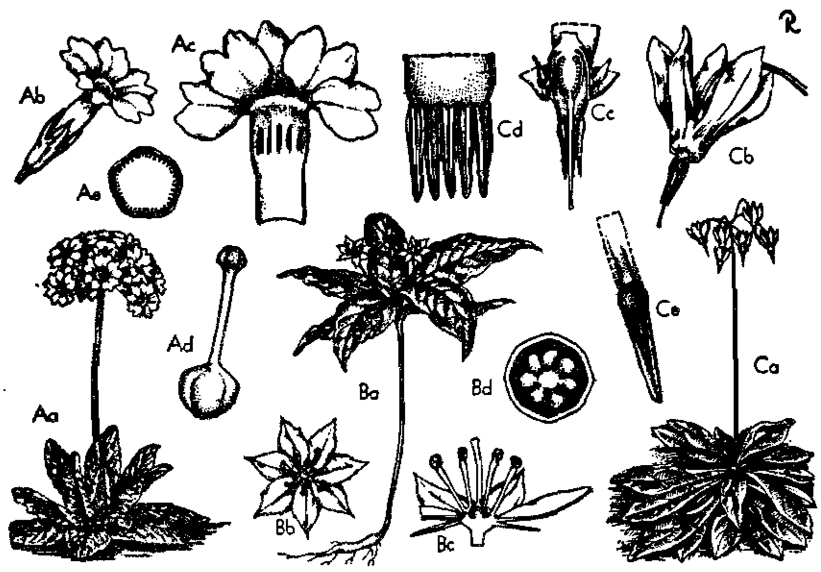

Fig. 63. PRIMULACEAE. A, *Primula denticulata:* Aa, plant in flower; Ab, flower; Ac, perianth, expanded; Ad, pistil; Ae, ovary, cross-section. B, *Trientalis borealis:* Ba, plant in flower; Bb, flower, face view; Bc, same, vertical section (perianth partially excised); Bd, ovary, cross-section. C, *Dodecatheon Media:* Ca, plant in flower; Cb, flower; Cc, same, vertical section (perianth partially excised).

Apocynaceae—Dogbane Family

Most members of this family produce a milky latex and generally have opposite decussate leaves. The flowers are actinomorphic, with the corolla contorted in bud, usually salverform or funnelform, and often is appendaged within. The pistil consists of two superior ovaries (unilocular and with marginal placentation) terminated by a single style and stigma. The stamens are borne on the corolla, alternate with the corolla-lobes, and produce granular pollen.

Asclepiadaceae—Milkweed Family (Fig. 64)

A family with many characters similar to those of the Apocynaceae, but it differs from them in the ovaries terminated by separate styles and an enlarged single, usually five-lobed massive stigma (Fig. 64 e). Furthermore, the five stamens are usually adnate to the stigma, with the pollen agglutinated into *pollinia* united in pairs. Each pollinium bears a *translator* arm (or connective) with the two adjoining arms meeting in a gland-like body (Fig. 64 d). In *Asclepias,* and some other genera, the corolla-tube is crowned by a corona that arises from the corolla, and a corona-horn represents sterile staminal appendages arising from the filament or anther. The fruit is a follicle.

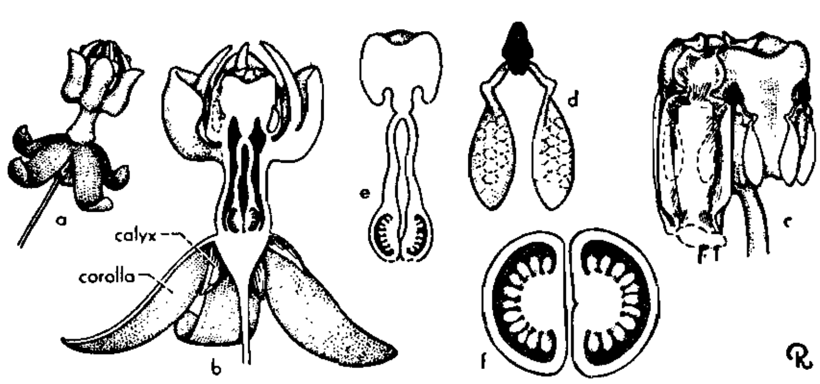

Fig. 64. ASCLEPIADACEAE. *Asclepias curassavica:* a, flower; b, same, vertical section; c, top of gynandrium, showing five-lobed stigma and anthers (corona excised); d, pollinia; e, pistil, vertical section; f, pistil, cross-section through the two ovaries.

Boraginaceae—Borage Family (Fig. 65)

The borages are a family of usually scabrous or hispid hairy plants with alternate leaves, terete stems, and whose inflorescence is a circinate helicoid cyme or aggregation of same. The flowers are mostly actinomorphic. The corollas are often with toothlike faucal appendages or scales (Fig. 65 Ac). The five stamens are borne on the corolla. There is a single pistil with a superior ovary that is two-carpelled and bilocular (but seemingly four-loculed at maturity). The placentation is seemingly basal but actually axile. The four ovules present in the ovary develop into four nutlets or a four-seeded drupe.

Verbenaceae—Verbena Family

Members of this family usually have opposite leaves and the flowers are arranged in one or another form of a cyme, but never circinnate nor

Fig. 65. BORAGINACEAE. A, *Symphytum asperum:* Aa, flowering branch; Ab, cymule; Ac, flower; Ad, same, vertical section; Ae, corolla expanded; Af, ovary, habit; Ag, same, vertical section. B, *Anchusa azurea:* Ba, portion of flowering branch; Bb, flower; Bc, nutlet. C. *Echium plantagineum:* flowers. D, *Heliotropium arborescens:* Da, flowering branch; Db, flower; Dc, pistil; Dd, same, vertical section. (From L. H. Bailey, *Manual of cultivated plants,* The Macmillan Company, 1949. Copyright 1924 and 1949 by Liberty H. Bailey.)

helicoid. The stamens are commonly four and didynamous. The ovary is not lobed apically and the style is terminal to it.

Labiatae—Mint Family (Fig. 66)

A family predominately of herbs, the mint has four-sided stems, opposite leaves, and the herbage characteristically aromatic when crushed. The flowers are in axillary pairs of dichasial or circinnate cymes often congested and spicate. The flowers are mostly zygomorphic and bilabiate, the stamens two or four (and then didynamous), and the superior ovary is deeply four-lobed apically with a gynobasic style (Fig. 66 d). The fruit usually consists of four nutlets.

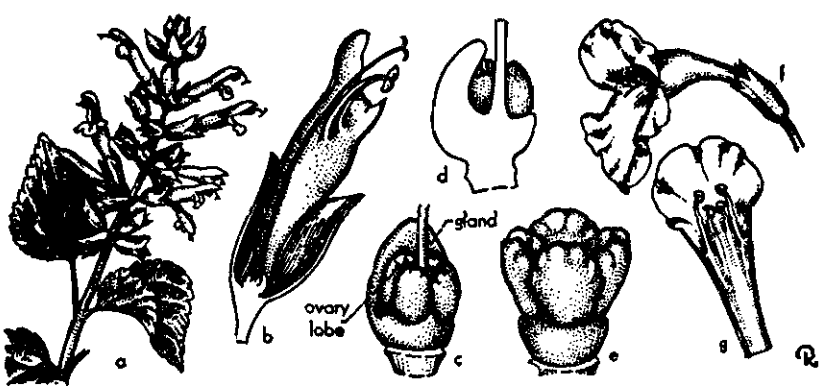

Fig. 66. LABIATAE. *Salvia splendens:* a, flowering branch; b, flower, vertical section; c, base of pistil; d, same, vertical section; e, fruit of four nutlets. *Stachys grandiflora:* f, flower; g, same, corolla expanded. (Adapted from L. H. Bailey, *Manual of cultivated plants,* The Macmillan Company, 1949.)

Solanaceae—Nightshade Family

These are mostly glandular plants whose herbage is variously odiferous when crushed. The inflorescence is cymose and the flowers are usually actinomorphic with plicate corolla. The androecium is commonly of four didynamous stamens (a fifth is usually represented by a staminode). The gynoecium consists of a single pistil with a superior usually bilocular ovary having axile placentation and a single style with a two-lobed stigma. The fruit is a berry or capsule.

Scrophulariaceae—Figwort Family (Fig. 67)

This family has many characters in common with the Solanaceae, but differs in the corolla not plicate and usually zygomorphic. In some members the corolla develops posteriorly into a swollen ventricle or spur, and in some the throat (such as in snapdragon) is closed by a fold called the palate.

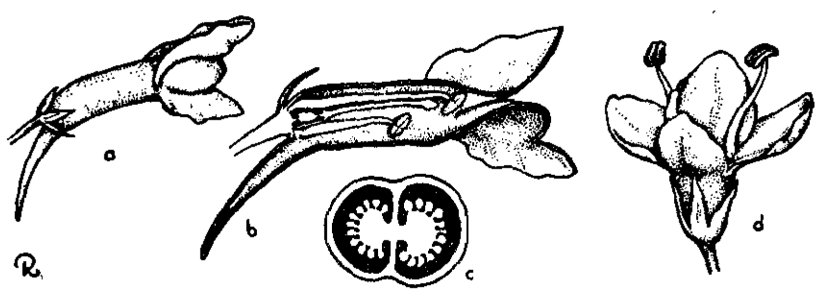

Fig. 67. SCROPHULARIACEAE. *Linaria vulgaris:* a, flower, side view; b, same, vertical section; c, same, cross-section of ovary. *Veronica longifolia:* d, habit of flower.

Rubiaceae—Madder Family

These trees and shrubs, infrequently herbs, are characterized by leaves opposite or whorled and provided with stipules; the inflorescence cymose and the flowers generally are actinomorphic (corollas often salverform). The stamens are as many as corolla-lobes and the pistil has a usually inferior ovary that is commonly bilocular with axile placentation.

Caprifoliaceae—Honeysuckle Family

This family is so closely allied to the Madder family that the two have been united by some authors. There is no single character by which they can be distinguished, except that in general the leaves of the Caprifoliaceae are without stipules.

Cucurbitaceae—Gourd Family (Fig. 68)

A family of mostly monoecious or dioecious tendril-bearing herbaceous vines, the gourd has leaves which are usually palmately or pinnately five-lobed or divided. The staminate flowers are highly variable as to number and arrangement of stamens. The pistillate flowers have an inferior ovary of three to five carpels with parietal placentation (sometimes axillary). The fruit is a berry with a hard or leathery rind and is termed a pepo.

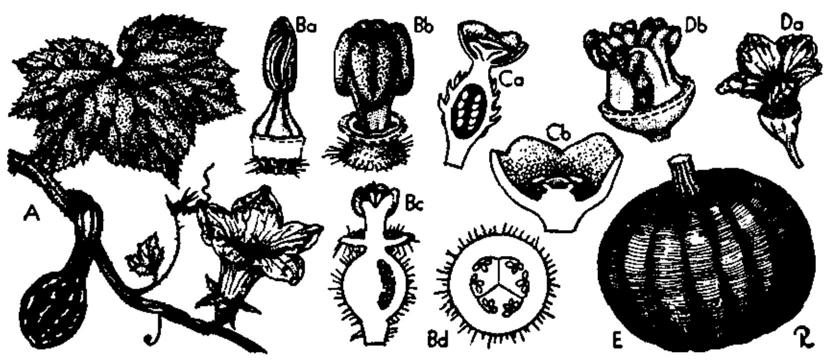

Fig. 68. Cucurbitaceae. A, *Cucurbita Pepo* var *ovifera:* branch with fruit and pistillate flower. B, *Cucurbita maxima:* Ba, staminate flower, less perianth; Bb, pistillate flower, less perianth and ovary; Bc, pistillate flower, vertical section, less perianth; Bd, ovary, cross-section. C, *Cyclanthera explodens:* Ca, pistillate flower, vertical section; Cb, staminate flower, vertical section. D, *Mormordica Balsaminea:* Da, staminate flower; Db, same, less perianth. E, *Cucurbita Pepo:* fruit, much reduced.

Campanulaceae—Bellflower Family

The bellflower family is one composed mostly of herbs, often with milky latex, whose bisexual flowers have actinomorphic or zygomorphic corollas. The stamens are five and may be distinct, connivent or syngenesious. The ovary is inferior, usually three- or five-carpelled and -loculed, with axile placentation (unilocular with parietal placentation in a few genera). The fruit is usually a capsule, dehiscing commonly by apical or basal pores.

Compositae—Aster Family (Fig. 69)

This is a very large and complex family, but its members are characterized by having inflorescence and floral characters in common. The inflorescence is a head or capitulum of few to many flowers borne on a receptacle. Each flower may have one or more chaffy or scarious bracts at its base (Fig. 69 d). The outside of the receptacle bears few to many involucral bracts or phyllaries (Fig. 69 b) that may be distinct or completely fused to form a tubo-like structure (as in marigold). The flowers (usually termed florets) are typically of two types: when both types are present in a single head, the inner ones are termed *disc* or *tubular* florets, and the outer are *ray* or *ligulate* florets (Fig. 69 a). The *disc floret* typically has a tubular five-lobed corolla from whose base rises five syngenesious stamens (connate by their anthers to form a cylinder about the style). The ovary is inferior and bicarpellate, but contains a single locule and ovule. There is a single style terminated usually by two stigmatic branches (becoming recurved at anthesis). The calyx is generally represented by bristles or scales (or both) arising from the top of the ovary and is termed the *pappus* (Fig. 69 d). The *ray floret* is a modified disc floret whose corolla is split down one side and become

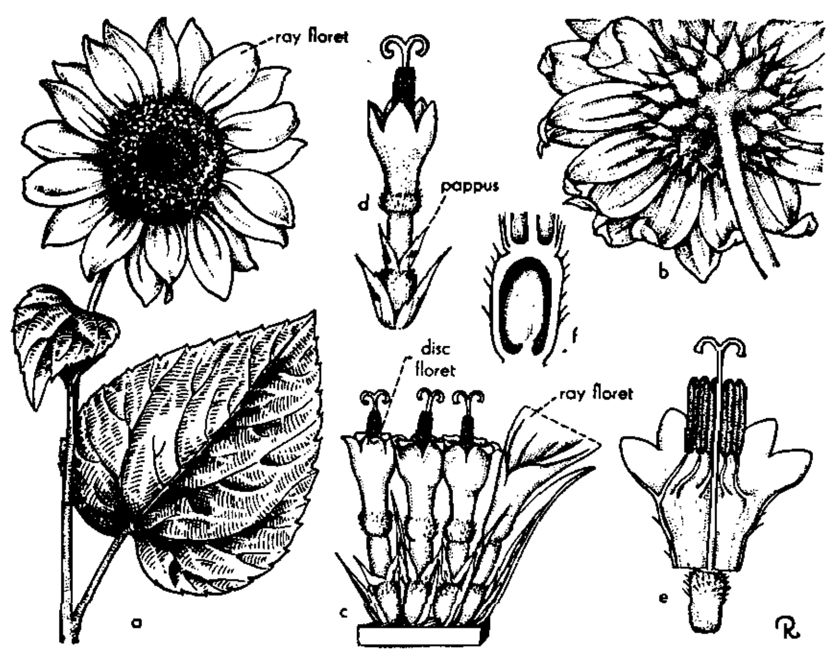

Fig. 69. COMPOSITAE. *Helianthus annuus:* a, head, face view; b, same, back view; c, section of receptacle to show disc florets and one-ray floret (corolla partially excised); d, disc floret; e, same, corolla and stamens expanded.

expanded. Very often the androecium is lost and the flower is unisexual (i.e., pistillate) and sometimes it lacks both sex element and is neuter. The fruit is an achene and the pappus is often persistent. In some genera the plants produce heads of only ray flowers, termed *radiate* heads (as in dandelion) in which cases the ray florets are bisexual. In others, only disc flowers are produced, and the heads then termed discoid (as in *Antennaria*). The characters of the inflorescence, ovary and androecium combined serve to separate this family from all others.

GLOSSARY AND INDEX

THE FOLLOWING comprises a combined index to this book and a glossary to taxonomic terminology as required by current American works on the identification and nomenclature of vascular plants. In it are intercalated those parts of the work dealing with biosystematics, phylogeny, and historical background. Terms discussed, or defined in the several chapters of this book are followed by the pertinent page reference and their definition is not repeated here. Many of the definitions have been taken without change from Lawrence, *Taxonomy of Vascular Plants.*

Abaxial, p. 71 (in footnote).
Abortive. Defective; barren; imperfectly developed.
Abrams, Leroy, p. 114.
Abrupt. Changing suddenly rather than gradually, as a leaf that is narrowed quickly to a point, not tapering; also a pinnately compound leaf that has no terminal leaflet.
Acaulescent, p. 36.
Accessory fruit, p. 79.
Accrescent. Becoming enlarged with age, as the sepals of some flowers.
Accumbent. Lying against and face to face, as some cotyledons (Fig. 38D), p. 83.
Acephalous. Without a head.
Acerose. Needle-shaped.
Achene, p. 81.
Achlamydeous. Lacking a perianth, without calyx or corolla.
Acicle. A very slender prickle or stiff bristle.
Acicular, p. 44.
Acropetal. Arising or developing in a longitudinal plane from a lower to a more apical level, the opposite of basipetal. *See* Centripetal.
Actinomorphic, p. 61–62.
Aculeate. Covered with prickles.
Acuminate, p. 44.
Acute, p. 45.
Acyclic. Arranged in spirals, not in whorls.
Adaxial, p. 71 (in footnote).
Adherent. Unlike parts in close contact, but not fused.

Adnate, p. 63 (in footnote).
Advanced characters, pp. 99–101.
Adventitious Buds. Buds appearing on occasion, rather than resident in regular places and order, as those arising about wounds.
Adventitive. A nonindigenous plant that has become established in a plant community but which is not expanding its area of occupation appreciably.
Aestival. Said of a plant appearing in summer.
Aestivation. The arrangement of the perianth or its parts in the bud, p. 66 (Fig. 30). Vernation is the leaf arrangement in the bud.
Aggregate fruit, p. 80.
Alate. Winged.
Albumen. Starchy or other nutritive material accompanying the embryo in the seed; commonly used in the sense of endosperm, for the material surrounding the embryo.
Alliaceous. Having the smell or taste of onions or garlic.
Alternate. Any arrangement of leaves or other parts not opposite or whorled; one part at a node; placed singly at different heights on the axis or stem (Fig. 19a).
Alveolate. Appearing like a honeycomb, with angular depressions separated by thin partitions, often in hexagonal form.
Alveoli. Pits or depressions resembling a honeycomb.
Amaranthaceae, described, pp. 129–130.
Amaryllidaceae, described, pp. 123–124.
Ament, p. 60 and Fig. 60.
Amphicarpous. Producing two kinds of fruits.
Amphigean. Native to both the New and Old Worlds.
Amphiploid (Amphidiploid). A type of polyploid characterized by the addition of both sets of chromosomes from each of two species.
Amphitropous, p. 75.
Amplexicaul. Clasping the stem.
Ampulla. A bladder, as in *Utricularia*.
Anastomosing, pp. 29, 31.
Anatropous, p. 76 (*Fig. 38Ac*).
Ancipital. Two-edged.
Androecium, defined, p. 65; types illustrated, p. 68.
Androgynophore. An axis or stalk bearing both stamens and pistil above the point of perianth attachment.
Androgynous. Said of an inflorescence composed of both staminate and pistillate flowers, with the staminate at the apex, as in some members of the Cyperaceae.
Androdioecious. Having staminate flowers on one plant and bisexual flowers on another.
Andromonoecious. Having male and bisexual flowers on the same plant.
Androphore. A stalk bearing the androecium.
Anemophilous, p. 69.
Angiosperms, characteristics of, p. 35.
Annual, p. 37.
Annulate, p. 55; annulate sporangia, p. 28.
Annulus, p. 28.
Anterior. Front; on the front side; away from the axis, adaxial; toward the subtending bract.
Antesepalous. Inserted opposite the point of insertion of the sepals.

Anther, p. 65; dehiscence types, 68; —sac, 66.
Antheridium. In Cryptogams, the organ producing male gametes or sperm.
Anthesis. Flowering; strictly, the time of expansion of a flower when pollination takes place, but often used to designate the flowering period; the act of flowering.
Antrorse. Directed forward or upward.
Apetalous. Lacking petals.
Apex (pl. *Apices*). The tip or distal end; for terms of, *see* pp. 44–45.
Aphyllous. Leafless.
Apiculate, p. 45 and Fig. 15i.
Apocarpous. With the pistils (carpels) separate, not united; frequently applied to a gynoecium of separate pistils; the opposite of *Syncarpous*.
Apocynaceae, described, pp. 139–140.
Apomict, p. 24.
Apopetalous, p. 63.
Apophysis. The exposed swollen part of a cone-scale, as in *Pinus*.
Aposepalous, p. 63.
Appendage. An attached subsidiary or secondary part, sometimes projecting or hanging; for appendaged anthers, *see* pp. 67–68.
Appendicular Theory, p. 77.
Appressed. Closely and flatly pressed against; adpressed.
Apterous. Without wings; the opposite of *Alate*.
Araceae, described, p. 122.
Arachnose, p. 51.
Archegonium, p. 27.
Arcuate. Curved or bowed.
Areolate. Reticulate, netted, marked out into small spaces by venation pattern, p. 55.
Areole, *see* Fig. 22; of leaf venation, p. 31.
Aril. An appendage or an outer covering of a seed, arising from or near the hilum or funiculus; sometimes appearing as if pulpy.
Arillate. Provided with an aril.
Aristate, p. 44 (Fig. 15b).
Aristotle, p. 7.
Armature. Any covering or occurrence of spines, barbs, hooks, or prickles.
Armed. Provided with any strong or sharp defense, as spines, thorns, or barbs.
Arrangement of leaves, terms of, pp. 48–49.
Articulate. Jointed; provided with nodes or joints or places where separation may naturally take place.
Arum family, described, p. 122.
Ascending, p. 36.
Ascidium. A cup- or pitcher-shaped organ, as in *Nepenthes* leaves.
Asexual. Sexless; without involvement or influence of gametes.
Asclepiadaceae, described, p. 140.
Asperous, p. 51.
Assurgent. Ascending, rising.
Aster Family, described, pp. 144–145.
Attenuate, p. 45 (Fig. 16a).
Auricle. An ear-shaped part or appendage, as the projections at the base of some leaves and petals.
Auriculate, p. 46 (Fig. 16g).
Author citation, pp. 93–94.

Autoploid. A polyploid in which each of the three or more chromosome sets has been derived from the same species. *See also* Amphiploid.
Autotrophic. Neither parasitic nor saprophytic.
Awl-shaped. Narrow and sharp-pointed; gradually tapering from base to a slender or stiff point.
Awn. A bristle-like part or appendage.
Axil, p. 36.
Axile Placentation, p. 74 (Fig. 36a).
Axillary. In, or arising from, an axil.
Axis. The main line of development; the main stem, *see* p. 36.

Baccate. Berry-like; pulpy or fleshy.
Banks, Sir Joseph, p. 104.
Banner Petal, p. 63.
Barbed, p. 52 (Fig. 22h).
Barbellate. Minutely or finely barbed.
Barbulate. Finely or minutely bearded.
Barnhart, J. H., p. 114.
Barton, B. S., p. 105.
Bartram, John, p. 104.
Basal Placentation, pp. 71, 74.
Bases, terms of, pp. 45–46.
Basifixed, p. 66.
Basipetal. Developing in a longitudinal plane from an apical or distal point toward the base, the opposite of *Acropetal. See* Centrifugal.
Basonym. The original epithet assigned to a species (or taxon of lower rank), which is usually retained when transferred to a new position.
Bast. The inner bark, usually fibrous in texture.
Beard. A long awn or bristle-like hair, as in some grasses; a tuft, line or zone of pubescence, as in some perianth parts.
Beech family, described, p. 128.
Bellflower family, described, p. 144.
Bentham, George, p. 9.
Berry, p. 82.
Bessey, Charles E., pp. 12–14.
Betulaceae, described, pp. 127–128.
Biciliate. Provided with two cilia or elaters, as in some motile sperm or spores.
Biennial, p. 37.
Bifid. Two-cleft, as the apices of some petals or leaves.
Bifurcate. Forked, as in some Y-shaped hairs, stigmas, or styles.
Bigelow, Jacob, p. 105.
Bilabiate, p. 64.
Binary, *name, contrasted with binary epithet,* p. 23.
Binomial, pp. 23, 91.
Biosystematics, pp. 98–102; defined, p. 98; units of, p. 102.
Biotype. A genotypic population.
Bipinnate. Twice or doubly pinnate, p. 41 (Fig. 13f).
Bipinnatifid. Twice or doubly pinnatifid.
Birch family, described, pp. 127–128.
Biseriate. In two whorls or cycles, as a perianth composed of a calyx and a corolla (Fig. 27).
Bisexual, p. 61.

Bladdery. Inflated; the walls thin, like the distended bladder of an animal.
Blade. The expanded part of a leaf or petal.
Bloom. A whitish, finely powdery covering of the surface, often waxy, as on some grapes.

Bostryx. A helicoid cyme.
Botuliform. Sausage-shaped.
Brachiate. With spreading armlike branches.

Bracteate. Bearing bracts.

Bractlet. A bract borne on a secondary axis, as on the pedicel or even on the petiole; a bracteole.
Branchlet. The ultimate division of a branch; the current year's growth; a twig.
Bristle. A stiff hair or seta; like a hog's bristle.
Bristly. Bearing stiff strong hairs or bristles.

Bulb-tunic. A usually membranous or fibrous coat enveloping a bulb; types of, p. 38.

Bursicule. The pouchlike expansion of the stigma, as that of some orchids and in which the caudicle of the pollinium is inserted.

Caducous. Falling off early, p. 56.

Calathiform. Cup-shaped.
Calcarate. Having or produced into a spur.
Caliciform. Calyx-like.
Callosity. A thickened raised area, often paler in color; the presence of a callus.
Calyculate. Calyx-like; bearing a part resembling a calyx; more commonly, provided with bracts against or beneath the calyx and resembling a supplementary calyx.
Calyculus. A simulated calyx, composed of bracts or bractlets.
Calyptra. A hood or lid; particularly that of a moss capsule; the lid in the fruit of eucalyptus, or the form of the calyx as in some papaveraceous flowers.

Calyx Tube. The tube of a gamosepalous calyx, *see* p. 78; sometimes employed for hypanthium, which see.

Canaliculate. With a channel or groove.

Cancellate. Resembling latticework.
Candolle, *see* de Candolle.
Canescent. Gray-pubescent; hoary or becoming so.
Cap. A convex removable covering, as of a capsule; in the grape, the cohering petals falling off as a cap.
Capillary. Hairlike; very slender.
Capitalization of species names, p. 95.
Capitate. Headed; in heads; formed like a head.
Capitulum. A dense inflorescence composed of an aggregation of usually sessile or near-sessile flowers, p. 59.
Caprifoliaceae, described, p. 143.
Capsular. Pertaining to or formed like a capsule.
Capsule, pp. 80, 81.
Carinal. Keeled, especially when the keel contains other floral parts.
Carinate. Keeled; provided with a projecting central longitudinal line or ridge, often on the dorsal or adaxial surface.
Carpel. One of the foliar units of a compound ovary or pistil; a foliar, usually ovule-bearing unit of a simple ovary, two or more combined by connation in the origin or development of a compound ovary; a female- or megasporophyll of an angiosperm flower. *See* Pistil. For discussion, see Lawrence, *Taxonomy of Vascular Plants,* pp. 72–75.
Carpellate. Possessing or composed of carpels.
Carpophore, pp. 81, 138.
Carrot family, described, pp. 137–138.
Cartilaginous. Tough and hard, but bony; gristly.
Caruncle. A callus-like appendage at or about the hilum of a seed, often paler in color than the seed coat.
Caryophyllaceae, described, p. 130.
Caryopsis, p. 122.
Castaneous. Of chestnut color; dark brown.
Catkin. A scaly-bracted, usually flexuous, spikelike "inflorescence" of cymules; prominent in the willows, birches, and oaks. *See* p. 60.
Caudate, p. 44 (Fig. 15c).
Caudex. Stem, p. 36.
Caudicle. The stalk of an orchid pollinium, usually thread- or strap-shaped. Not to be confused with the stalk of the pollinium in some Asclepiadaceae, which is termed a Translator Arm.
Caulescent. Having an evident stem above ground. *See* p. 36.
Cauline, p. 49.
Centralium. A central lengthwise cavity, as found in the seeds of some palms.
Centrifugal. Developing from the center outwards.
Centripetal. Developing from the outside toward the center.
Centrum. The center of a solid.
Cernuous. Nodding; drooping.
Cesalpinaceous Corolla, p. 63.
Cespitose, p. 36.
Chaff. A small thin, dry, membranous scale or bract; in particular, the bracts in the flower heads of the Composites.
Chalaza. The basal part of an ovule where it is attached to the funiculus (Fig. 38).
Chapman, A. W., pp. 114–115.
Chartaceous. Of papery or tissue-like texture and not usually green in color.
Chenopodiaceae, described, p. 129.

Choripetalous. Having separate and distinct petals; polypetalous.
Cilia. Hairs arising from the margin; eyelash-like.
Ciliate, p. 47.
Ciliolate. Diminutive of ciliate; minutely ciliate.
Cincinnus, p. 59.
Cinereous. Ash-colored.
Circinate, p. 30.
Circumscissile, p. 81.
Cirrhous, pp. 37, 44.
Citation of authors' names, pp. 93–94.
Cladophyll, p. 38.
Clambering, p. 37.
Clasping. Partly or wholly surrounding the stem.
Class, a unit of classification, pp. 21, 22.
Classification, defined, p. 2; phylogenetic systems of, pp. 6–18; units of, pp. 21–22.
Clavate. Club-shaped, like a baseball bat. *See* p. 53, Fig. 22f.
Clavellate. Diminutive of clavate.
Claw. The long narrow, often petiole-like, base of petals and sepals of some flowers.
Clayton, John, p. 103.
Cleft, p. 48.
Cleistogamous Flowers. Small, closed, self-fertilized flowers, as in some violets and many other plants; they are mostly on, near, or under the ground.
Climbing, p. 37.
Clinandrium. The pouch or "anther-bed" in monandrous orchids; that part of the gynandrium of an orchid flower in which the pollinia are concealed.
Clone, pp. 22, 24.
Coaetaneous. Flowering as the leaves expand.
Coalescence. Cohesion; the incomplete fusion or sticking together of like parts (as petals to petals); sometimes loosely used synonymously with connation, which is the complete fusion of like parts.
Coccus (plural *Cocci*). A berry; in particular, one of the parts of a lobed or deeply divided fruit when each part is one-seeded, sometimes these parts may be leathery or even dry.
Cochleate. Spiral, like a snail shell.
Code of nomenclature, p. 89.
Coherent. Like parts in close contact but not fused.
Collecting techniques, pp. 84–87.
Collinson, Peter, p. 104.
Colonial. Forming colonies, usually by underground parts.
Columella. The central axis (carpophore) supporting one of the halves (mericarps) of the fruit of Umbelliferae, sometimes restricted to the basal unbranched portion.
Column, p. 125.
Coma. A tuft of hairs, as on *Asclepias* seeds; a leafy crown or head, as in some palm trees.
Commissural Face, p. 138.
Comose. Provided with a coma, or tuft of hairs, or resembling such.
Comparium, p. 102.
Compositae, described, pp. 144–145.
Compound. Of two or more parts or components; *leaf*, pp. 40–41; *ovary* or *pistil*, pp. 71–74.
Compressed. Flattened laterally. *See* Obcompressed.

Concave. Shallowly hollowed; saucer-like.
Concolorous. Uniformly colored.
Conduplicate, p. 83.
Cone. A dense and usually elongated assemblage of fertile sporophylls on a central axis, each often subtended by a bract.
Confluent. Merging or blending together.
Congeneric. Belonging to the same genus.
Coniferales, characteristics of, pp. 33–35.
Connate. United or joined; particularly when two or more like parts are united, as petals fused to one another by their margins in a gamopetalous corolla.
Connate-perfoliate, p. 46.
Connective. The filament or tissue connecting the two cells or thecae of an anther, more obvious when the two thecae are separated by this intervening tissue.
Connivent. Coming together or converging but not fused; coherent; the parts often arching (treated by some authors as synonymous with adherent).
Conoidal. Nearly conical.
Conservation of names, p. 91.
Contiguous, p. 30.
Contorted. Twisted; convolute in aestivation.
Convex. Rounded outward.
Convolute. Said of floral envelopes in the bud (as parts of corolla or calyx) when one edge overlaps the next part (petal, sepal or lobe) while the other edge or margin is overlapped by a preceding part; rolled, the margins overlapping. *See* Fig. 30c.
Cordate, p. 46.
Cordiform. Shaped like a heart.
Coriaceous. Of leathery texture.
Corm, p. 38.
Cormel, p. 38.
Corolla, p. 63; types of, pp. 63–65.
Corona, of Amaryllidaceae, p. 125; of Asclepiadaceae, p. 140.
Corylaceae, p. 127.
Corymb, p. 61.
Costa. A rib, the midvein of a simple leaf; less commonly the rachis of a pinnately compound leaf.
Costapalmate. Said of a palmate palm leaf whose petiole continues through the blade, forming a distinct midrib, as in the palmetto.
Costate. Ribbed; having one or more, usually raised, longitudinal ribs or nerves.
Cotyledon. The seed leaf; the primary leaf or leaves in the embryo; in some plants the cotyledon always remains within the seed coat, while in others (as in the bean) it emerges on germination. For cotyledon positions, *see* p. 83 and Fig. 38.
Cotyloid. Concave or cup-shaped, as the receptacle of *Calycanthus.*
Coulter, J. M., p. 111.
Coville, F., p. 117.
Crassulaceae, described, pp. 131–132.
Crateriform. Shaped like a saucer or cup.
Creeper. A trailing shoot that takes root mostly throughout its length; sometimes applied to a tight-clinging vine.
Cremocarp. A dry, dehiscent, two-seeded fruit of the Umbellifer family; a schizocarp.
Crenate, p. 47.

Crenulate. Diminutive of crenate; finely waved in a vertical plane.
Crested. With a ridge that is irregular, elevated and often toothed, or appearing as if so.
Crispate. Curled, an extreme form of undulate.
Crisp-hairy. Provided with hairs that are curled and somewhat kinky.
Cristate. Bearing a crestlike appendage.
Crosier, p. 30.
Crown. A corona; that part of the stem situated at the surface of the ground; a series of appendages in the throat of a corolla.
Cruciferae, described, p. 131; figured, p. 132.
Cruciform Corolla. Cross-shaped, the petal or corolla-lobes usually four. *See* p. 63.
Cryptogam. A plant reproducing by spores instead of by seeds, as ferns, mosses, algae, fungi. *See* pp. 27–31.
Cucullate. Hooded or hood-shaped.
Cucurbitaceae, described, pp. 143–144.
Culm. Stem, particularly that of a grass.
Cultigen. Plant or group known only in cultivation; presumed to have originated under domestication; the opposite of indigen.
Cultivar. A variety or race that has originated and persisted under cultivation, not necessarily referable to a botanical species.
Cuneate, p. 45.
Cuneiform, p. 43.
Cupressaceae, p. 35.
Cupule. Cuplike structure at the base of some fruits (as in some palms) formed by the dry and enlarged floral envelopes; also the cup of an acorn.
Cuspidate, p. 45.
Cyathium. A type of inflorescence characteristic of *Euphorbia;* the unisexual flowers condensed and congested within a bracteate envelope from which they emerge at anthesis.
Cycadales, characteristics of, p. 32.
Cyclic. Arranged in whorls; the opposite of spiralled.
Cymbiform. Boat-shaped.
Cyme, p. 57.
Cymose. Cyme-like inflorescence.
Cymule, p. 59.
Cyperaceae, described, p. 122.
Cypsela. An achene bearing an adnate calyx, as in some Compositae.
Cystolith. A stone-like concretion of calcium deposit in the epidermis of some plants, as in the nettles.
Cytogenetics, p. 101.

Darlington, William, p. 106.
Darwin, Charles, p. 9.
de Candolle, A. P., p. 8.
Deciduous. Falling at the end of one season of growth or life, as the leaves of non-evergreen trees.
Declinate. Bent downward or forward, the tips often recurved.
Decompound. More than once compound (Fig. 15f, g).
Decumbent. Reclining or lying on the ground, but the end ascending (Fig. 106).
Decurrent. Extending down and adnate to the stem, as the leaf base of *Verbascum*.
Decussate. Opposite leaves in four rows, up and down the stem, alternating in pairs with each pair at right angles to the one above and below (Fig. 19d).

Deflexed. Reflexed.

Dehiscence. The method or process of opening; for that of anthers, *see* p. 68, and of fruits, *see* pp. 80–81.

de Jussieu, classification system, 8.

Deliquescent. Having the primary axis or stem much-branched above, as in an elm tree; the opposite of *Excurrent;* said also of perianth parts that quickly soften and deteriorate in a few minutes to hours after picking, in *Eichornia* or *Tradescantia.*

Deltoid. Triangular; delta-like, derived from the Greek letter, *delta* (Fig. 14p).

Dentate. With sharp, spreading, rather coarse indentations or teeth that are perpendicular to the margin (Fig. 17g).

Denticle. A minute tooth.

Denticulate. Minutely or finely dentate (Fig. 17h).

Depressed. More or less flattened endwise or from above; pressed down.

Determinate Inflorescence, p. 57.

Dextrorse. Clockwise; toward the right hand.

Diadelphous, p. 68, Fig. 32.

Dialypetalous. Polypetalous; a corolla of separate and distinct petals.

Diandrous. Having two stamens, as in *Veronica* or *Salvia.*

Dichasium, p. 57.

Dichotomous. Forked, in one or more pairs, *see* p. 36; a dichotomous key is one with couplets of opposing statements, *see* p. 85.

Dicotyledoneae, p. 127.

Diclesium. An achene enclosed within a free but persistent envelope.

Diclinous. Unisexual; requiring two flowers (or plants) to represent both sexes.

Didymous. In pairs, twins.

Didynamous. With four stamens, in two pairs and one pair of a different length (or height) than the other (Fig. 32a).

Diffuse. Loosely branching or spreading; of open growth.

Digitate. Handlike; the members arising from one point, as the leaflets of a horse-chestnut leaf. *See* Palmate.

Dimorphic. Occurring in two forms as in ferns (*see* p. 31) or having juvenile and adult foliage types as in *Eucalyptus* or *Hedera.*

Dioecious. Having staminate and pistillate flowers on different plants; a term properly applied to a taxonomic unit and not to flowers (*see* p. 61).

Diploid. A plant having two sets of chromosomes in its somatic nuclei; the opposite of *Haploid;* a plant may have a diploid number of chromosomes in its vegetative cells and a haploid number in its male and female nuclei (gametes).

Diplostemonous. Having the stamens in two whorls, those of the outer whorl alternate with the petals, and those of the inner whorl opposite the petals.

Dipterous. Two-winged.

Disc. A more or less fleshy or elevated development of the receptacle, or of the coalesced nectaries or staminodes, about the pistil; the receptacle in the head of the Composite flower; a flattened extremity, as on tendrils of Virginia creeper. The term is an anglicization of the Latin *discus,* and sometimes is spelled disk, and often so when used with reference to the Compositae.

Disc Floret. The tubular flower of some members of the Compositae (Fig. 69d).

Disciform. Circular and like a disc.

Discoid. Resembling a disc; used to designate a head of members of the Compositae when only disc flowers are present (the opposite of Radiate).

Discrete. Separate, not coherent or adherent. *See* Distinct.
Disk, see Disc.
Dissected. Divided into many slender segments.
Dissepiment. A partition, as in an ovary or fruit (not commonly used).
Distichous, p. 48.
Distinct. Separate; not connate nor coherent with other parts of the same series; e.g., the petals of a polypetalous flower are *distinct.* When petals are separate from sepals and not adnate to them, one is said to be *free* from the other. *Compare* Free.
Diurnal, p. 56.
Divaricate. Spreading very far apart; widely divergent.
Divergent. Spreading very broadly, but less so than when divaricate.
Divided. Separated to very near the base (or to the midrib).
Division, unit of classification, pp. 21, 22.
Dogbane family, described, pp. 139–140.
Dolabriform. Shaped like the head of an axe or hatchet.
Dorsal. Back; adaxial; relating to the back or outer surface of a part of an organ, as the lower side of a leaf, or the part of an organ away from the axis supporting it; the opposite ventral and abaxial. *See* p. 71.
Dorsifixed. Attached by the back; often, but not necessarily versatile, as the anthers in *Lilium* (Fig. 31 Db, Dc).
Dorsiventral. Flattened and provided with a definite dorsal and ventral surface; laminate; e.g., most foliaceous leaves are dorsiventral (or have dorsiventral surfaces) whereas the fruit of an orange does not have a dorsiventral surface.
Double-serrate. With coarse serrations bearing minute teeth on their margins.
Downy. Covered with very short and weak soft hairs.
Drake, Francis, p. 103.
Drupaceous. Resembling a drupe but morphologically not identical with one.
Drupe, p. 82 and Fig. 41 a, b.
Drupelet. One drupe of a fruit composed of an aggregation of miniature drupes, as in the raspberry, the so-called seed within a drupelet being a pyrene.
Drying specimens, p. 87.
Duct. A tube or canal which carries latex, resin, or oil.
Durand, Elias, p. 108.
Duration, terms of, pp. 36, 37.

E- or *ex-.* A Latin prefix often meaning without, as eciliate (without cilia) or exstipular (estipular) without stipules.
Ebracteate. Without bracts.
Echinate, p. 52.
Eciliate. Without cilia.
Ecospecies, p. 102.
Ecotype, p. 102.
Effective publication, p. 92.
Elater. A ribbon-like band which, in *Equisetum,* is hygroscopic, somewhat clavate, and aids in dispersal of the spores to each of which four elaters are attached.
Elliptic, p. 43.
Elongate. Lengthened; stretched out.
Emarginate, p. 45.
Embryo. The rudimentary plant within a seed, usually developing from a zygote.

Embryotega. A disclike callosity on the seed coat in species of Commelinaceae, Flagellariaceae, and Mayacaceae.

Enation. An epidermal outgrowth, often one cell thick.

Endarch. Said of a type of xylem whose development is toward the center of the axis (centripetal); the opposite of exarch.

Endemic. Native or confined naturally to a particular and usually restricted area or region; biologically a relic of once wide distribution.

Endocarp. The inner layer of the pericarp or fruit wall.

Endosperm. The starch- and oil-containing tissue of many seeds; often referred to as the albumen.

Engelmann, George, p. 115.

Engler, Adolf, pp. 10–12.

Ensiform. Sword-shaped.

Entire. With a continuous margin, not in any way indented. *See* p. 46.

Entomophilous, p. 69.

Envelopes, floral. The two series composing the perianth; the corolla and the calyx.

Ephedrales, p. 32.

Ephemeral, p. 56.

Epi-. A Greek prefix, signifying on or upon.

Epibiotic. A species which is a survival of a lost flora; a near-endemic.

Epigynous. Borne on or arising from the ovary; said of floral parts when the ovary is inferior and the flower not perigynous. The term is not applicable to the ovary itself.

Epipetalous. Borne on or arising from the corolla or petals.

Epiphyte. A plant growing on another or on some other elevated support.

Equitant. Overlapping in two ranks, as the leaves of *Iris* (Fig. 19j); astride, as one leaf astride another.

Ericaceae, described, pp. 138–139.

Erose. Said of a margin when appearing eroded or gnawed, or of a jaggedness too small to be fringed and too irregular to be toothed.

Estipulate. Without stipules.

Euphorbiaceae, described, p. 135.

Eusporangiate. Said of fern sporangia that have developed from a group of cells that first divided periclinally to produce inner (sporogenous-forming) and outer (sterile, sporangium-forming) layers of cells. *See* Leptosporangiate.

Evening-primrose family, described, p. 137.

Even-pinnate. A pinnately compound leaf lacking a terminal leaflet, with the total leaflets of an even number, pp. 40, 41.

Evergreen. Remaining green in its dormant season; sometimes applied to plants that are green throughout the year; properly applied to plants and not to leaves, but due to the persistence of leaves.

Evolution and phylogeny, pp. 98–101;—and units of classification, pp. 19–25.

Ex-. Prefix meaning without, or lacking.

Exasperate. Rough, with the papillae bearing hard, minutely projecting points.

Excurrent. Extending beyond the margin or tip, as a midrib developing into a mucro or awn; or, descriptive of the habit of a plant with a continuous unbranched axis, as *Picea* or *Abies.* The opposite of deliquescent.

Exfoliate. To peel off in shreds, thin layers, or plates, as bark from a tree trunk.

Exine, p. 69.

Exocarp. The outer layer of the pericarp or fruit wall.

Explanate. Flattened, spread out.

Exserted. Projecting beyond, as stamens from the mouth of a corolla. The opposite of included.
Exstipulate. Without stipules.
Extrorse. Looking or facing outward; said of anther dehiscence and best determined by making a cross section of an undehisced anther. *See* p. 68.
Eye. The marked center of a flower; a bud on a tuber; a single bud-cutting.

Fagaceae, described, p. 128.
Falcate. Sickle-shaped.
Falls. Outer whorl or series of perianth parts of an iridaceous flower, often broader than those of the inner series (the standards) and, in some *Iris*, drooping or flexuous.
Family, a unit of classification, pp. 21, 22–23; characterization of, pp. 119–145.
Farinaceous. Containing starch or starchlike materials; sometimes applied to a surface covered with a mealy coating, as leaves of some *Primula* spp.
Farinose. Covered with a meal-like powder. *See* p. 56.
Fasciate. Much flattened; an abnormal widening and flattening of the stem.
Fascicle. A condensed or close cluster, as of flowers, or of most pine leaves (Fig. 19f).
Fasciculate, p. 49.
Fastigiate. With branches erect and more or less appressed. *See* p. 36.
Faucal. Pertaining to the throat, as of a corolla. *Faucal Appendages* are small often toothlike appendages or enations arising from a corolla at its mouth, as in some Borages or members of Caryophyllaceae.
Faveolate. Honeycombed. *See* Alveolate, Foveolate.
Feather-veined. With the ribs all extending from the central midvein toward the margin and remaining simple or scarcely branched.
Fenestrate, p. 55.
Fernald, M. L., p. 112.
Ferns, characteristics of, pp. 27–31.
Ferruginous. Colored rust-red.
Fertile. Said of pollen-bearing stamens and seed-bearing fruits.
Fertilization. The union of two gametes (as the male nucleus from a germinating pollen grain, and the egg-nucleus of an ovule) to form a zygote (which, in seed plants, develops to form the embryo within a seed); not to be confused with pollination.
Fetid. Having a disagreeable odor.
Fibrilla. Diminutive of fiber.
-fid. Combining form denoting cleft; cut about halfway to the middle.
Figwort family, described, pp. 142–143.
Filament. Thread; particularly the stalk of a stamen (terminated by the anther). *See* p. 65.
Filamentous. Composed of threadlike strands.
Filicinae, pp. 27, 29.
Filiform, p. 42.
Fimbriate. Fringed.
Fimbrillate. Provided with a minute fringe.
Fistula. Tubular; hollow and cylindrical.
Flabellate. Fanshaped, as the leaf of Ginkgo or of Palmetto palm; broadly wedge-shaped.
Flaccid. Limp, floppy; wilted.
Flagelliform. Like a whiplash or a diminutive of it.

Flexuous. Having a more or less zigzag or wavy form; withy.
Floccose. Covered with tufts of soft woolly hairs that usually rub off readily.
Floral-cup, p. 78.
Floret. An individual flower, usually minute, especially of grasses and composites; any assemblage of small flowers that compose a compact type of inflorescence.
Floricane. The flowering and fruiting stem, especially of a bramble (Rubus), usually the second year's growth or development.
Floriferous. Flower-bearing.
Flower. An axis bearing one or more pistils, one or more stamens, or both; when only the former, it is a *pistillate flower*, when only the latter a *staminate flower*, when both sex elements are present it is a *perfect flower* (i.e., bisexual or hermaphroditic). When the perfect flower is surrounded by a perianth composed of two floral envelopes (the inner envelope the corolla, the outer the calyx), it is a *complete flower. See also* pp. 61–78.
Foliaceous. Leaflike; said particularly of sepals, calyx-lobes, and bracts that in size, texture, and color resemble small or large leaves.
Follicetum. An aggregation of follicles, distinct or basally connate, representing the product of an apocarpous multipistillate gynoecium.
Follicle, pp. 80–81.
Forma, a unit of classification, pp. 22, 24.
Foveolate, p. 55.
Fraser, J., p. 104.
Free. Not adnate or adherent to other organs; as petals free from the stamens or calyx; or, the veinlets (as in some ferns) not united but are free. Sometimes, and especially in older literature, the term is used in the sense of *distinct*.
Free-central Placentation, p. 74.
Frond. The leaf of a fern; sometimes used in the sense of foliage, especially of palms and cycads. *See* p. 30.
Frondose. Bearing fronds; leafy.
Fruit. The ripened ovary (pistil) with the adnate parts, the seed-bearing organ; it is applied also to the seed-bearing organ of gymnosperms, although not the product of a ripened ovary or pistil; in some works it is improperly applied to the fertile portions of a fern-leaf. For fruit types, *see* pp. 78–82.
Fruticose. Shrubby or shrublike in the sense of being woody.
Fugaceous, p. 56.
Fulvous. Tawny in color.
Funiculus, p. 75.
Funnelform. With the tube gradually widening upward and passing insensibly into the limb, and in many kinds of *Convolvulus;* infundibuliform (Fig. 28c).
Furcate. Forked.
Furrowed. With longitudinal channels or grooves.
Fuscous. Grayish brown.
Fusiform. Spindle-shaped; narrowed both ways from a swollen mid-region.

Galea. A helmet, as one sepal in an aconite flower, or the upper lip of some bilabiate corollas.
Galeate. Provided with a galea; hooded.

Gamete. A minute protoplasmic unit containing a single nucleus (whose chromosomes are usually of the haploid number) which on union with another, and usually unlike, gamete forms the zygote.

Gametophyte. The generation that bears the sex organs; in ferns, a thallus-like small or minute body bearing archegonia (the egg-containing organs) and antheridia (the sperm-producing organs); in the angiosperms reduced to the three-nucleate pollen-tube and the eight-nucleate (or -celled) embryo sac and contents. *See* p. 27.

Gamopetalous, p. 63.

Gamophyllous. With leaves, or foliar units, connate by their edges.

Gamosepalous, p. 63.

Geminate. Equal, in pairs.

Gemma. An asexual propagule sometimes appearing as, but not homologous with, a bud.

Geniculate. Bent like a knee. *See* p. 36.

Genotype. A type (plant or population) determined by genetical characters. *See* Phenotype.

Genus, a unit of classification, pp. 22, 23; nomenclatural considerations of, p. 91.

Gibbous, p. 65.

Ginkgoales, characteristics of, p. 33.

Glabrate (glabrescent). Nearly glabrous, or becoming glabrous with maturity or age.

Glabrous. Not hairy; often incorrectly used in the sense of *smooth.*

Gladiate. Sword-shaped, but may be straight or curved.

Gland. A secreting part or prominence or appendage, but often used in the sense of a glandlike body.

Glandular. Having or bearing glands or secreting organs.

Glandular-Pubescent. With glands and hairs intermixed, or hairs terminated by pinhead-like glands.

Glandular-Punctate. *See* Punctate.

Glanduliferous. Having or bearing glands.

Glaucescent. Slightly glaucous.

Glaucous. Covered with a bloom or whitish substance that rubs off.

Glochid. A minute barbed spine or bristle, often in tufts, as in some cacti (Fig. 22d).

Glochidiate. Barbed at the tip.

Glomerate. In dense compact cluster or clusters.

Glumaceous. Provided with or resembling glumes.

Glume, p. 122.

Glutinous. Sticky, or covered with a sticky exudate.

Gnetales, p. 32.

Goodale, G. L., p. 111.

Goosefoot family, described, p. 129.

Gourd family, described, pp. 143–144.

Gramineae, described, pp. 121–122.

Granulose. Covered with very small grains, or appearing as if so.

Grass family, described, pp. 121–122.

Grass Spikelet, p. 121.

Gray, Asa, p. 110.

Greene, E. L., p. 116.

Greenman, J. M., pp. 115–116.

Gregarious. Growing in large colonies.

Gronovius, J. F., p. 103.
Gymnosperms, characteristics of, pp. 31–35.
Gynandrium, p. 125.
Gynandrous. With the stamens adnate to or borne on the pistil.
Gynecandrous. With staminate and pistillate flowers in the same spikelike inflorescence and with the pistillate beneath the staminate.
Gynobase. An enlargement of the receptacle (axis) bearing the pistil.
Gynoecium. The female element of a flower; a collective term employed for the several pistils of a single flower when referred to as a unit; when only one pistil is present, pistil and gynoecium are synonymous. *See* pp. 69–78.
Gynophore. The ovary-bearing axis extended above the region of perianth attachment.
Gynostemium. The column (gynandrium) of an orchid flower, formed by adnation of stamens and the style and stigma.

Habit. The general appearance of a plant.
Habitat. The type of locality and immediate environment in which a plant grows.
Haft. The narrow constricted part of an organ or part.
Halberd-shaped. *See* Hastate, p. 46.
Half-inferior Ovary, p. 76.
Hamate. Hooked at the tip.
Hastate, p. 46.
Hastula. Terminal part of petiole on upper surface of leaf blade of a palmate-leaved palm, sometimes called the ligule (but not homologous with the ligule of the grass leaf).
Haustoria. The absorbing organs (often rootlike) of some parasitic plants and usually having the anatomy of a stem rather than of a root.
Head. A short dense inflorescence of sessile (or nearly sessile) flowers, situated on an axis that is much compressed vertically and sometimes flattened or saucer-shaped. *See* p. 59.
Heath family, described, pp. 138–139.
Helicoid Cyme, p. 57.
Hemi-. In Greek compounds, signifying half.
Herbaceous, p. 37.
Herbarium, pp. 86–87.
Hermaphrodite. With stamens and pistil in the same flower. *See* p. 61.
Hesperidium, p. 80.
Hetero-. In Greek compounds, meaning two or more sorts.
Heterocarpous. Producing more than one kind of fruit.
Heterogamous. Bearing two or more types of flowers in one cluster, as in *Compositae*.
Heterosporous. A state of producing two kinds or sizes of spores, as in *Selaginella*. *See* p. 27.
Heterostyly. A state of flowers of a given plant or taxon possessing styles of different length ratios to the stamens or corolla, or other parts, as in *Primula*.
Hexa-. In Greek compounds, meaning in numbers of six.
Hexamerous. Its parts in sixes.
Hibernaculum (pl. *hibernacula*). A winter bud or an underground stem; a dormant, resting bud.
Hickory family, described, p. 127.
Hiemal. Relating to winter.
Hilum, pp. 75, 82.

Hip. The fruiting structure of a rose (*Rosa*), whose fleshy portion is composed of receptacle and hypanthium, and the achenes included within.
Hippocrepiform. Horseshoe-shaped.
Hirsute, pp. 51, 54.
Hirsutulous. Slightly or approaching hirsute.
Hirtellous. Minutely hirsute.
Hispid, pp. 52, 54.
Hispidulous, pp. 52, 54.
Hoary. Grayish white and very fine pubescence.
Holotype, p. 91.
Homogamous. A head or cluster with flowers all of one kind, with stigmas becoming receptive at the time pollen is shed in the same flower.
Homologous. Of similar origin, but differing in form or function, as the perianth parts of a flower being homologous with the leaves.
Homonym. Two or more names of a plant (or epithets) with identical spelling, but applied to two taxa. *See also* p. 95.
Homosporous. The state of producing spores of one kind, as opposed to heterosporous; *see also* p. 27.
Honeysuckle family, described, p. 143.
Hooker, J. D., p. 9.
Howe, M. A., p. 113–114.
Humifuse. Spreading over the surface of the ground.
Husk. An outer, usually loose, covering of some fruits, as in *Physalis*.
Hutchinson, J., pp. 14–16.
Hyaline, p. 56.
Hybrid. A cross between two taxa; usually a cross between two species of a genus or genera.
Hybridization, defined, p. 19.
Hygroscopic. A changing of form or position through changes in moisture content.
Hypanthium, p. 78 and Fig. 39.
Hypocotyl. The axis or stem of a seedling below the cotyledons. *See* p. 82.
Hypocrateriform. Salver-shaped, see salverform.
Hypogynium. A perianth-like structure subtending and usually enveloping the ovary in some members of the *Cyperaceae*.
Hypogynous. Inserted below the gynoecium and free from it.
Hysteranthous, p. 56.

Icosandrous. With twenty or more stamens.
Identification, defined, p. 1; procedures of, pp. 85–86.
Identifying techniques, pp. 84–87.
Illegitimate names, explained, p. 90; when rejected, pp. 94–95.
Imbricate, p. 49.
Immersed. Completely submerged, in water or plant tissues.
Imparipinnate. Odd-pinnate, with a terminal leaflet.
Imperfect Flower. A flower lacking either male or female sex organs. *See* p. 61.
Incarnate. Flesh colored.
Incised, p. 47.
Included. Not protruded beyond the enveloping structure, as stamens may be included within the corolla-tube; not exserted.
Incomplete Flower. A flower lacking one of the perianth whorls, as calyx or corolla, or both. *See* Imperfect Flower.

Incubous. With the tip of one leaf overlapping the base of the leaf above, but not to the extent of being imbricate.

Incumbent. Leaning or resting on; cotyledons are incumbent when the back of one rests against the radicle; stamens are incumbent when dehiscing toward the floral axis (introrse).

Incurved. Gradually curving inward.

Indehiscent. Remaining closed; not splitting open at maturity along regular lines of fusion.

Indeterminate Inflorescence, p. 57.

Indigen. A native; as contrasted with a cultigen (growing under cultivation), a naturalized plant (thoroughly established but coming from a foreign region), an adventive (somewhat naturalized but unable to compete in its new environment).

Indigenous. Native to the country or region.

Indumetnum, p. 49.

Induplicate. With the edges turned inward, and the external surfaces then coherent or connate.

Indurate. Hard, as spines may become indurated (hardened) with maturity.

Indusiate. Provided with an indusium.

Indusium, p. 30.

Induviate. Clothed with old and withered parts.

Inermis. Unarmed; not prickly; spineless.

Inferior Ovary, p. 76; origin of, pp. 76–78.

Inflexed. Turned abruptly inward.

Inflorescence, pp. 56–61; terms of, p. 57.

Infra-. Latin prefix, meaning below.

Infrapetiolar Bud, described, p. 40.

Infraspecific Units of classification, pp. 24, 91.

Infundibular, p. 64.

Innate. Borne at the apex of the supporting structure; an innate anther is one attached at its base to the filament tip (i.e., basifixed).

Innovation. A lateral branch or offshoot from the stem, usually restricted to new growth.

Insectiverous. Said of plants that capture insects.

Inserted. Growing out from, seemingly borne on.

Integument. A covering or envelope, that which envelopes; specifically, the one or two envelopes that cover (and are a part of) the ovule; *see* p. 75.

Inter-. Latin prefix, meaning between.

International Code of Botanical Nomenclature, p. 89.

Internode. That part of an axis between two nodes; *see* p. 36.

Intra-. Latin prefix, meaning within.

Introrse, p. 68.

Invalid names, p. 90.

Involucel. A secondary involucre, as the umbellet of the Umbelliferae.

Involucre, p. 59.

Involute. Rolled inwards from the edges, the dorsal surface outermost.

Iridaceae, described, p. 125.

Iris family, described, p. 125.

Irregular Flower, p. 62.

Isoetaceae, p. 28.

Isomerous. The same number in successive whorls.

Isotype. A specimen of the same collection as the holotype.

Jepson, W. L., pp. 116–117.
Jointed. Separable into pieces at one or more points.
Juglandaceae, described, p. 127.
Jugum. Latin, meaning a pair, as of leaflets.

Kalm, P., p. 104.
Karyotype. The nature of the chromosomal complex characteristic of the individual or taxon.
Keel. A projecting longitudinal ridge, like the keel of a boat; carinate.
Keel Petal, p. 63.
Kermesine. Carmine red.
Key, and use of, pp. 85–86.
Key, a samara-type of dry indehiscent winged fruit, as in Ash (*Fraxinus*).

Labellum. The usually enlarged petal of an orchid flower. *See* p. 125.
Labels, data for, p. 87.
Labiatae, described, p. 142.
Lacerate, p. 47.
Laciniate, p. 47.
Lactescent. Producing milky juice, as does the Milkweed.
Lacticiferous. Latex-containing; yielding a milky juice.
Lacuna. A chamber, hole, or gap; an air space within a tissue.
Lacustrine. Belonging to or occurring in lakes.
Laevigate. Smooth, as if polished.
Lamarckism, p. 20.
Lamella. A flat plate, sometimes a partial or complete partition.
Lamellate Placentation, p. 74.
Laminate. Expanded and flat, as the blade of a leaf.
Lanate, p. 51.
Lanceolate, p. 42.
Lanuginous, Cottony or woolly.
Lanulose. Woolly, sometimes spelled *lanose*.
Lappaceous. Resembling a Burdock burr; retrorsely echinate.
Lateral. Belonging to the side.
Lateritous. Brick red in color.
Lax. Loose in texture or arrangement; the opposite of crowded.
Leaf apex, terms of, pp. 44–45; bases, terms of, pp. 45–46; forms, pp. 42–44; margins, terms of, pp. 46–48; position, terms of, pp. 48–49; structure, pp. 40–41; surface, terms of, pp. 54–56; venation, pp. 41–42.
Leaflet, p. 40.
Lectotype, pp. 91–92.
Legitimate name, p. 90.
Legume, pp. 80, 81.
Leguminosae, described, p. 134.
Lemma, p. 122.
Lenticel. Lens-shaped corky dots, or pits on young bark.
Lenticular. Lens-shaped, usually biconvexly so.
Lepidote. Provided with small scurfy scales.
Liane (*liana*). A woody tropical vine that climbs or clambers over other plants. *See* p. 36.
Ligneous. Woody.

Ligulate Floret. A flower of the Compositae family whose corolla is strap-shaped. *See* p. 65.
Ligule. The membranous appendage at the top of leaf sheaths of most grasses. *See* Fig. 44c.
Liguliform. Strap-shaped.
Liliaceae, described, p. 123.
Lily family, described, p. 123.
Limb. The expanded portion of a petal or leaf, especially of a gamopetalous corolla.
Lindley, J., p. 8.
Linear, p. 42.
Lineate, p. 55.
Lineolate. Bearing fine linelike markings.
Lingulate. Tongue-shaped.
Linnaeus, C., pp. 7–8.
Lip. The principal lobes of a bilabiate corolla or calyx.
Littoral. Belonging to the shore.
Livid. Pale gray, lead-colored.
Lobe, p. 47.
Lobulate. Cut into small lobes.
Locule, p. 69.
Loculicidal, p. 81.
Lodicule. One of the small scalelike processes outside the stamens of a grass flower, believed to represent the vestigial perianth remains.
Loment, pp. 80, 81.
Lorate, p. 42.
Lotoideae, p. 134.
Lunate. Crescent-shaped.
Lupuline. Resembling hops.
Lurid. Dingy, dirty.
Lusus. An abnormal variation or sport, a mutant form.
Luteolus. Yellowish, pale yellow.
Lycopsid. A taxon of the *Lycopodium* alliance, a club-moss or relative of it.
Lycopsida, p. 27.
Lyrate. Pinnately lobed, with the terminal lobe the largest and laterals becoming progressively smaller toward the base.

Macrosporangium. The spore-case that produces macrospores.
Macrospore. See Megaspore, p. 27.
Maculate. Blotched or spotted.
Madder family, described, p. 143.
Mailing specimens for identification, p. 87.
Mallow family, described, p. 135.
Malpighiaceous Hairs. Hairs that are straight but which are attached at the middle, often found on members of the Malpighiaceae, but also on plants of other families.
Malvaceae, described, p. 135.
Mamillate. Bearing teat-shaped protuberances.
Manubrium. The constricted stalklike basal portion of boat-shaped spathes in some palms.
Marcescent, p. 56.
Marginal Placentation, p. 71.
Marmorate. Marbled.

Meristem. An embryonic tissue of cells capable of dividing and producing new growth.

Mesocarp. The middle layer of a pericarp (ovary or fruit wall).
Mesophyte. Plants of medium moisture and light requirements, intermediate between those of very dry and very wet environments.

Midrib. The middle or main rib of a leaf.

Miniate. Dull vermilion, the color of red lead.

Mitriform. Mitre-shaped; like a peaked cap.

Monocephalic. Bearing one head, often one headlike inflorescence.
Monochasium. A one-branched cyme, usually resulting from reduction of laterals, sometimes appearing raceme-like, as in lily-of-the-valley (*Convallaria*).
Monochlamydeous. A perianth of a single envelope or whorl, i.e. of calyx or corolla.
Monocolpate. One-furrowed, as the pollen grains of many monocots. *See* p. 69.

Monogynous. A flower bearing a single pistil.
Monopetalous. The petals fused into a single unit (obsolete).

Monotypic. A genus of one species.

Motile. Said of sperm when provided cilia, flagella, or other locomotion accessories.

Mucronulate. Diminuitive of mucronate. *See* Fig. 15 h.

Multicarpellate. A pistil of many carpels; sometimes used for a gynoecium of many pistils.
Multicipital. Many headed.

Multifid. Cleft into many segments of lobes.
Multiple Fruit, p. 80.
Muricate, p. 55.
Muriform. Resembling courses of bricks in a wall.
Mustard family, described, p. 131.
Mutation, pp. 19–20.
Muticous. Blunt, lacking a point.

Naked Flower. One lacking a perianth; a *naked bud* is one lacking bud scales.
Names, capitalization of, p. 95; conservation of, p. 91; when illegitimate, pp. 94–95; when rejected, pp. 94–95.
Napiform. Turnip-shaped.
Nascent. In the act of being formed.
National Herbarium, pp. 117–118.
Natural Selection, p. 19.
Naturalized. Introduced from a foreign country and established naturally in the new environment.
Navicular. Boat-shaped, as the glumes of most grasses.
Nectariferous. Having one or more nectaries.
Nectary. A nectar-secreting organ. *See* p. 66.
Nemorose. Inhabiting groves.
Neotype, p. 92.
Nerve. A vein, as of a leaf-blade, perianth part, or carpel.
Netted. Said of veins when branched to form a network.
Neutral Flower. A "flower" having neither stamens nor pistils; sexless.
New York Botanical Garden, p. 112.
New York school of taxonomy, p. 112.
Nightshade family, described, p. 142.
Nigrescent. Becoming black, or nearly so.
Nitid. Shining.
Niveous. Snow white.
Nocturnal. Opening at night. *See* p. 56.
Node, p. 36.
Nodule. A small knob or knot.
Nomen conservandum, p. 91.
Nomenclature, p. 88; of cultivated plants, p. 97; defined, p. 2.
Nucellus, p. 75.
Nuciform. Nut-shaped.
Nude Flower, p. 61.
Nut, p. 81.
Nutlet, p. 81.
Nuttall, T., pp. 107–108.
Nycti-. Latin prefix denoting night.

Ob-. A Latin prefix, signifying over, against, inverted.
Obconical. Inversely conical, attached at the apex of a cone-shaped structure.
Obcordate, p. 45.
Obdiplostemonous. Having the stamens in two whorls, those of the outer whorl opposite the petals, and those of the inner whorl alternate with the petals.
Oblanceolate, p. 43.
Oblate. A sphere that has become flattened at the ends, as in a tangerine.
Oblique, p. 46.

Oblong, p. 43.
Obovate, p. 43.
Obovoid. A solid having the form of an inverted egg.
Obsolescent. Vestigial, nearly extinct.
Obsolete. Not evident, extinct.
Obtuse, pp. 45, 46.
Ochrea, p. 128.
Ochroleucous. Yellowish white to buff colored.
Ocreolae. Small secondary leaf-sheaths, as in *Eriogonum*.
Odd-pinnate. Pinnately compound with an odd number of leaflets. *See* p. 40.
Oligo-. A Greek prefix, signifying few, as *oligospermous* (few seeded).
Olivaceous. Olive-green.
Onagraceae, described, p. 137.
Opaque. As applied to a surface, one that is dull and not shining.
Operculate. Provided with a lid, or operculum.
Operculum, p. 81.
Opposite, p. 49.
Orbicular, p. 44.
Order, discussion of, pp. 21, 22–23.
Orpine family, description of, pp. 131–132.
Orthos-. Greek prefix for straight.
Orthotropous, p. 75.
Osseous. Of a bony texture.
Ovary, origin of, pp. 69–74; position, 76–78.
Ovate, p. 42.
Ovulate. Bearing ovules, *ovuliferous* a synonym.
Ovule, pp. 75–76.

Palate. A projection or intruding fold that partially closes the throat of a corolla. *See* p. 65.
Palea, p. 122.
Paleaceous. Provided with chaff, or chaffy in texture.
Paleobotany. Fossil botany, the study of plants as they occurred in the geologic past.
Palmate Venation, p. 42.
Palmately Compound, p. 40.
Palmatifid, p. 48.
Paludose. Inhabiting marshes.
Pandurate, p. 44.
Panicle, p. 60.
Pannose. Covered with a felt of woolly hairs.
Papaveraceae, described, p. 131.
Papilionaceous, p. 63.
Papilionatae, *see Lotoideae*, p. 134.
Papillate, p. 55.
Pappus, p. 63 and Fig. 42.
Parallel Venation, p. 42.
Parasite. Botanically, a plant living on and deriving nourishment from another plant.
Parietal Placentation, p. 73.
Paripinnate. Pinnate with an even number of leaflets.
Parted, p. 48.

Parthenogenesis. The development, in plants, of a sporophyte from a female gamete without fertilization or syngamy.
Patelliform. Rather thickly disc-shaped, like the knee-cap (*patella*).
Patent. Open, spreading.
Pea family, described, p. 134.
Pectinate. Divided like the teeth of a comb.
Pedate. Like a bird's foot, sometimes treated as a synonym of palmate.
Pedicel, p. 57.
Peduncle, p. 57.
Peg. A stalk, applied to the stalk of an ovary or fruit when not composed of ovarian (carpellary) tissue, as in the peanut (*Arachis*).
Pellucid. Clear, transparent or nearly so.
Peltate, p. 46.
Pendulous. Somewhat drooping.
Penicillate. Tipped with a tuft of fine hairs, as the stigmas of some grasses.
Penninerved. Pinnately veined. *See* p. 42.
Penta-. A Greek prefix, signifying five.
Pentamerous. In units of five or multiples of five.
Pepo, p. 80.
Perennate. Lasting the whole year through; self-renewing by lateral shoots from the base.
Perennial, p. 37.
Perfect Flower, p. 61.
Perfoliate, p. 46.
Pergamtaceous. Parchment-like.
Perianth, pp. 62–63.
Perigynium, p. 122.
Perigone. A synonym of perianth.
Perigynous. Borne or arising from around the ovary and not beneath it, as when perianth segments and stamens seemingly arise from the edge of a cup-shaped hypanthium; such cases are said to exhibit perigyny.
Periphery. The outer wall or margin; the inner face or side of the ovary wall, as opposed to the faces of its septa.
Persistent. Remaining attached; not falling off.
Personate. Said of a two-lipped corolla, the throat of which is closed by a palate, as in toadflax. *See* p. 65.
Pertuse. Perforated with a hole or slit.
Perulate. Scale-bearing, as most buds.
Petal, p. 63.
Petalody. The metamorphosis of stamens into petals, etc.
Petaloid. Petal-like; in color and shape resembling a petal.
Petiole, p. 40.
Petiolule, p. 40.
Phanerogam. A seed plant or spermatophyte, as opposed to a cryptogam.
Phenotype. A plant or population determined by its appearance, as opposed to a genotype, which is determined by genetic characters.
Phloem. A complex tissue of the vascular anatomy containing sieve tubes, phloem parenchyma, and other elements such as fibers, stone cells, companion cells, etc.; the inner bark of a woody plant; the outer two tissues of a vascular strand (the xylem the inner one).
Phyllary, p. 60.

Phylloclade. A branch, more or less flattened, functioning as a leaf, as in Christmas cactus.
Phyllodium. Leaflike petiole with no blade, as in some acacias and some other plants.
Phyllotaxy. The arrangement of leaves or floral parts on an axis.
Phylogenetic classifications, discussed, pp. 100–101.
Phylogeny, functions of, pp. 98–101; systems of, p. 9.
Phylum. One of the primary divisions of the plant or animal kingdom whose components are presumed to have had a common ancestry. *See* pp. 21–22.
Pilose, p. 51.
Pink family, described, p. 130.
Pinna, p. 31.
Pinnate, pp. 40, 41, 42.
Pinnatifid, p. 48.
Pinnatisect. Cut down to the midrib in a pinnate fashion.
Pinnule, p. 31.
Pisciform. Pea-shaped.
Pistil, pp. 69–70.
Pistillate. Female; having one or more pistils and no functional stamens.
Pistillode. A rudimentary or vestigial pistil present in some staminate flowers.
Pith. The soft spongy central cylinder of parenchyma tissue in most woody angiosperm stems.
Placenta, p. 70.
Placentation Types, pp. 70–74.
Plant classification, pp. 2, 6–18.
Plant identification, procedures, p. 26.
Plicate. Folded, as in a fan, or approaching this condition.
Plumose, pp. 52, 53.
Plumule. Of a young plant, the first shoot above the cotyledons.
Pod. A dehiscent dry fruit.
Pollen Grains, pp. 68–69.
Pollen Sac. The microsporangium, containing the pollen; in most angiosperms each anther is composed of four pollen sacs, two in each lobe or half of the anther, the tissues separating them disintegrating prior to anthesis and the resulting anther seemingly two-celled or biloculate.
Pollination. The transfer of pollen from the dehiscing anther to the receptive stigma; the act of pollinating.
Pollinium, p. 69; in orchids, p. 126; in Asclepiadaceae, p. 140.
Polyandry. The production of an indefinite number of stamens in an androecium.
Polycarpic, p. 56.
Polygamodioecious. Said of a species that is functionally dioecious but has a few flowers of the opposite sex or a few bisexual flowers on all plants at flowering time.
Polygamous. Bearing unisexual and bisexual flowers on the same plant.
Polygonaceae, described, pp. 128–129.
Polypetalous, p. 63.
Polymorphic. Represented by two or more forms, as is a species of several closely related infraspecific taxa.
Polyphylesis. A situation representing a polyphyletic origin (*see* p. 20); that is, the result of evolution along two or more lines, having different origins.
Polyphyletic, p. 20.

Polyploid. Having a chromosome complement of more than two sets of the monoploid number.
Polypodiaceae, p. 120.
Polysepalous. Having a calyx of separate sepals.
Pome, p. 80.
Poppy family, described, p. 131.
Poricidal dehiscence, pp. 68, 81.
Preservation of plant specimens, pp. 86–87.
Pressing plants, p. 86.
Prickle. A small weak spinelike body on the bark or epidermis.
Primitive vs. advanced characters, pp. 99–101.
Primordium. A group of undifferentiated meristematic cells capable of differentiating into various kinds of organs or tissues.
Primulaceae, described, p. 139.
Priority of names, p. 91.
Procumbent, p. 36.
Prostrate. A general term for lying flat on the ground.
Protandrous (Proterandrous), p. 69.
Protantherous, p. 56.
Protogynous. A flower whose stigma is receptive to pollen before pollen is shed from anthers of the same flower. *See* p. 69.
Pruinose, p. 56.
Pseudoterminal Bud, p. 39.
Pseudobulb. The thickened or bulbiform stems of certain orchids, being solid and borne above the ground.
Psilopsida, p. 27.
Pteropsida, pp. 15, 17.
Puberulent, pp. 50, 54.
Puberulous, p. 50.
Pubescent, p. 50.
Pulle, A., p. 16.
Pulverulent, p. 56.
Pulvinate. Cushion-shaped.
Pulviniform. Having the shape of a pulvinus; pad- or cushion-shaped.
Pulvinus. A minute gland or swollen petiole (or petiolule) base responsive to vibrations, heat, or some other stimuli, as in the leaves of Sensitive plant (*Mimosa*).
Punctate, p. 55.
Pungent. Ending in a stiff sharp point or tip; also, acrid to the taste.
Pursh, Frederick, p. 107.
Pustular. Blistery, often minutely so.
Pyrene, p. 82.
Pyriform. Pear-shaped.
Pyxis, p. 81.

Raceme, p. 60.
Racemose. Having flowers in raceme-like inflorescences that may or may not be true racemes.
Rachilla. A secondary or diminutive axis, or rachis; in particular, in the grasses and sedges, the floret-bearing axis.
Rachis, p. 31.

Radiate. Standing on and spreading from a common center; also, having ray flowers, as in the Compositae.
Radical. Said of leaves that are basal or in rosettes; arising from the root or its crown.
Radicle. The embryonic root of a germinating seed. *See* p. 82.
Rafinesque, C. S., pp. 108–109.
Ramiform. Branching.
Rank. A vertical row; leaves that are two-ranked are in two vertical rows.
Ranunculaceae, described, pp. 130, 131.
Raphe. That portion of a funiculus of an ovule that is adnate to the integument, usually represented by a ridge, present in most anatropous ovules, diagnostic in *Sarracenia*. *See also* p. 82.
Raphides, p. 122.
Rattan, V., p. 116.
Ray, John, p. 6.
Ray. Outer modified floret of some composites, with an extended or strap-shaped part to the corolla; also a branch (pedicel or peduncle) of an umbel or umbel-like inflorescence.
Receptacle, p. 60.
Receptacular Theory, p. 78.
Reclinate. Bent down or falling back from the perpendicular.
Reflexed. Abruptly bent downward or backward, usually a 180° change of direction, or nearly so.
Regular Flower. A symmetrical flower with the parts in each series or set so arranged as to be divisible vertically into equal halves by two or more planes.
Reniform. Kidney-shaped. *See* p. 44.
Repand. Weakly sinuate.
Repent, p. 36.
Replum. Partition between two loculi of cruciferous fruits. *See Cruciferae*.
Resinous. Containing or producing resin, said of bud scales when coated with a sticky exudate of resin (as in some *Aesculus* spp.).
Resupinate. Twisted 180°, as the ovary (and flower) of most orchids; upside down.
Reticulate. Netted. *See* p. 54.
Reticulate Venation, pp. 29, 31.
Retrorse. Bent or turned backward or downward.
Retuse, p. 45.
Revolute. Rolled backward; with margin rolled toward lower side.
Rhizoid. A rootlike structure in function and general appearance, but not so in anatomy.
Rhizomatous. Producing or possessing rhizomes.
Rhizome, p. 37.
Rhizophore. A leafless stem that produces roots, as in *Selaginella*.
Rhombate, Rhomboidal. Shaped like a rhomboid. *See* p. 44.
Rib. Any prominent nerve or vein in a leaf or similar organ.
Robinson, Benjamin L., p. 111.
Rodgers, A. D. III, botanical biographies by, p. 118.
Roridulate, p. 56.
Rosaceae, described, p. 133.
Rostellum. A small beak.
Rostrate. Having a beak or beaklike projection.

Rosulate. In rosettes.
Rotate Corolla, p. 64.
Rotund. Orbicular, inclining to be oblong.
Rubiceae, described, p. 143.
Rudimentary. Imperfectly developed, vestigial.
Rugose, p. 54.
Ruminate. Mottled in appearance; a tissue of dark and light zones of irregular outline.
Runcinate, p. 43.
Runner. A slender trailing shoot, rooting at the nodes.
Rydberg, Per Axel, p. 113.

Saccate. Bag-shaped, pouchy.
Sagittate, p. 46.
Salicaceae, described, p. 127.
Salverform, p. 64.
Salviniaceae, pp. 28, 120.
Samara, p. 81.
Saprophyte. A plant (usually lacking chlorophyll) living on dead organic matter.
Sarmentose. Producing long flexuous runners or stolons.
Saxifragaceae, described, p. 132.
Scabrescent, p. 52.
Scabrous, p. 52.
Scale. Any small, usually dry, appressed leaf or bract, often only vestigial.
Scandent. Climbing.
Scape, pp. 57, 61.
Scapose, pp. 36, 61.
Scarious, p. 56.
Schizaeaceae, p. 120.
Schizocarp, p. 81.
Schmaltz, C. Rafinesque, pp. 108–109.
Scorpioid Cyme, pp. 57, 59.
Scrophulariaceae, described, pp. 142–143.
Scutate. Like a small shield.
Secund. One-sided, or seemingly so.
Sedge family, described, p. 122.
Seed. The ripened ovule; the essential part is the embryo, usually contained within one or two integuments. *See* pp. 82–83.
Segment. One of the divisions of a leaf, petal, sepal, or bract that is divided but not compound.
Sepal, p. 63.
Sepaloid. Said of an involucral bract or petal that resembles a sepal.
Septate. Partitioned; divided by partitions.
Septicidal. Dehiscence along or into the partition (septum), not opening directly into the locule. *See also* p. 81.
Septum (pl. *septa*). A partition or cross-wall.
Sericeous. Silky. *See* pp. 51, 54.
Serrate, p. 47.
Serrulate, p. 47.
Sessile. Not stalked.
Seta. A bristle.
Setaceous. Bearing bristles.

Setose, pp. 52, 54.
Setulose, p. 52.
Shaw, Henry, p. 115.
Sheath. Any long more or less tubular structure surrounding an organ or part.
Shrub. A woody plant that remains low and produces shoots or trunks from the base; not treelike nor with a single bole; a descriptive term not subject to precise circumscription.
Sigmoid. *S*-shaped.
Siliceous. Containing minute particles of silica.
Silicle. The short fruit of certain Cruciferae, usually not more than twice as long as broad.
Silique. The long slender fruit of certain Cruciferae.
Sinuate, p. 46.
Sinus. The space or recess between two lobes or divisions of a leaf or other expanded organ.
Small, J. K., p. 114.
Soboliferous, p. 36.
Solanaceae, described, p. 142.
Sorus (pl. *sori*), p. 30.
Spadix, pp. 60, 122.
Spathaceous. Resembling or furnished with a spathe.
Spathe, pp. 60, 123.
Spathe-Valves. One or more herbaceous or scarious bracts that subtend an inflorescence or flower, and generally envelop the subtended unit when in bud
Spatulate (Spathulate), p. 43.
Species, pp. 22, 23–24.
Specimens, preparation of, pp. 86–87.
Sperm. A male gamete or reproductive cell.
Sphenopsid. Any of a group of *Equisetum*- or horsetail-like plants.
Sphenopsida, p. 27.
Spicate. Spikelike.
Spicule. A diminutive or secondary spike.
Spike, p. 60.
Spikelet, p. 121.
Spine. A strong, sharp-pointed woody body mostly arising from the wood of a stem.
Spinescent. Terminated by a spine, or bearing spinelike teeth.
Spinulose. With small spines over the surface.
Sporangium, p. 28.
Spore, p. 27.
Sporocarp. A body or receptacle containing sporangia (as in *Marsilea*).
Sporophyll. A spore-bearing leaf (as in ferns); a leaflike organ bearing reproductive parts or organs.
Sporophyte, p. 27.
Spurge family, described, p. 135.
Squamate. With small scalelike leaves or bracts; scaly.
Squamelliform, p. 52.
Squamose. Covered with small scales, more coarsely so than when lepidote.
Stalk. The stem of any organ, as the petiole, peduncle, pedicel, filament, stipe.
Stalked Bud. One whose outer scales are attached above the base of the bud axis. *See also* p. 39.
Stamen, pp. 65–69.

Staminate. Furnished with stamens, but no functional pistil; male.
Staminode, pp. 66, 68.
Standard. The upper and broad, more or less erect petal of a papilionaceous flower (*see* p. 63); the narrow, usually erect, unit of the inner series of the perianth in an *Iris* flower as opposed to the often drooping falls. *See* p. 125.
Stellate, pp. 52, 53.
Stems, pp. 35–39.
Sterile. Lacking any functional sex organs.
Stigma, pp. 69, 74–75.
Stipe, p. 31.
Stipel. The stipule subtending a leaflet.
Stipule. A basal appendage of a petiole; the three parts of a complete leaf are blade, petiole, and stipules (usually two in number). *See* p. 40.
Stolon. A shoot that bends to the ground and takes root; more commonly, a horizontal stem at or below the surface of the ground that gives rise to a new plant at its tip; *stoloniferous. See* p. 36.
Stomate. The pore in a leaf (usually on the lower side) formed by the concavity of two facing sausage-like guard cells.
Stone. A large pyrene; *stone fruit,* a drupe or drupelet, as in Rosaceae.
Stramineous. Straw colored.
Striate, p. 55.
Strict. Straight and upright, little if at all branched.
Strigose, pp. 51, 54.
Strobile (strobilus), p. 33.
Stylar. Within the style or stigma; pertaining to the style.
Style, pp. 74, 75.
Stylopodium. A disclike enlargement at the base of the style, as in some umbellifers. *See* p. 81.
Sub-. As a prefix usually signifying somewhat, slightly, or rather.
Suberose, p. 56.
Subinferior Ovary, p. 76.
Subpetiolar. Under the petiole base, and usually enveloped by it.
Subspecies, p. 24.
Subulate, p. 44.
Succulent. Juicy; fleshy; soft and thickened in texture.
Suffrutescent, p. 37.
Sulcate, p. 55.
Superior Ovary, p. 76.
Superposed Buds, p. 40.
Supine. Lying flat and with face upward.
Surface, terms of, pp. 54–56.
Suture. A line or mark of splitting open; a groove marking a natural division or union.
Syconium. The "fruit" of a fig, actually an inverted and essentially closed receptacle containing many achenes.
Sym-. See under syn-.
Symmetrical. Said of an actinomorphic flower that has the same number of parts in each series or circle, as five petals, five stamens, etc.
Symphysis. The connation of like parts from time of meristematic development, as petals in the gamopetalous type of corolla.
Sympodial Inflorescence. A determinate inflorescence that simulates an indeterminate inflorescence, as a scorpioid cyme (*compare* latter also with helicoid cyme).

Syn-. A prefix from the Greek, meaning with, together, like. *Syn-* becomes *sym-* before *b*, *m*, and *p*, and then has the same meaning.
Synandrium. An androecium coherent by the anthers, as in some aroids; when anthers are connate they are termed syngenesious.
Synantherous, p. 56.
Syncarpous. Having carpels united; applied to an ovary of two or more carpels; sometimes used when separate pistils within one flower are partially united. *See* Apocarpous.
Syngenesious, p. 67.
Synonym. An equivalent superseded name; a second name for a given taxon.
Synpetalous. Gamopetalous; the petals marginally connate, at least basally.
Synsepalous. Gamosepalous; the sepals marginally connate, at least basally.

Tailed. Said of anthers having caudal (tail-like) appendages.
Taxaceae, p. 33.
Taxon (pl. *taxa*). A general term applied to any taxonomic element, population, or group, irrespective of its classification level. *See* p. 13.
Taxonomy, defined, p. 1; in North America, pp. 103–118; opportunities in, p. 4; significance of, p. 3.
Tendril. A rotating or twisting threadlike process or extension by which a plant grasps an object and clings to it for support; morphologically it may be stem or leaf or leaflet.
Tepal, p. 62.
Terete. Circular in transverse section.
Ternate. In threes.
Terrestrial. On the ground; a land plant, as opposed to aquatics, epiphytes, or saprophytes.
Testa. Outer coat of a seed (developed from an integument).
Tetrad. A group of four; in angiosperms, a four-celled pollen-mother cell. *See* p. 69.
Tetradynamous, p. 67.
Tetramerous. Four-merous.
Tetrandrous. With four stamens.
Texture, terms of, p. 56.
Thalamus. The receptacle of a flower; Thalamiflorae, a taxon whose floral parts are hypogynous, distinct, and separate from one another on the receptacle.
Thallus. A flat leaflike organ.
Theca. The pollen sac of an anther. *See* p. 66.
Theophrastus, p. 7.
Thorn. Same as spine.
Throat. In flowers, the opening or mouth of the tube of a gamopetalous corolla; the place where the limb becomes differentiated from the tube.
Thyrse, p. 60.
Tippo, O., pp. 16–18.
Tomentose, pp. 50, 54.
Tomentulose, p. 50.
Torrey, John, p. 109.
Torulose. Twisted or knobby; irregularly swollen at close intervals.
Torus. Receptacle.
Tournefort, J. P., p. 7.
Transverse Dehiscence, p. 68.
Tree. A woody plant that produces one main trunk or bole, and a more or less distinct and elevated head.

Trelease, Wm., p. 115.
Tribe, p. 22.
Trichome. A hair or bristle. *See* p. 49.
Tricolpate. Three-grooved. *See* p. 69.
Trifoliate. Three-leaved, as in *Trillium*. *See* p. 41.
Trifoliolate. Having a leaf (or leaves) of three leaflets, as most clovers. *See* p. 41.
Trigonal. Three-angled, without regard for the acuteness or bluntness of the angles.
Triquetrous. Three-angled, and sharply so, the sides often somewhat concave, as in the stems of some sedges.
Triternate. Three times ternate, as in some Meadow-rues or Columbines.
Trivial Name. The specific name, as opposed to the generic name.
Truncate, p. 46.
Tuber, p. 38.
Tubular Corolla, p. 64.
Tumid. Swollen, somewhat inflated, as the portion of the trunk of the Belly palm.
Tunic, p. 38.
Turbinate. Inversely conical; top-shaped.
Turgid. Swollen from fullness, but not usually distended.
Turion. A young sucker or shoot, as an emerging stem of asparagus.
Twig. A young woody stem; more precisely the current season's growth of a branch.
Twining, p. 37.
Type Method, p. 91.
Typical element of a species, explained, pp. 95–96.

Umbel, p. 59.
Umbellate. With umbels, pertaining to umbels.
Umbellet. The secondary umbel of a compound umbellate inflorescence. *See* p. 59.
Umbelliferae, described, pp. 137–138.
Umbo. A small conical projection from the surface; a boss.
Umbraculiform. Umbrella-shaped.
Uncinate, pp. 52, 53.
Underground Stems, illustrated, p. 38.
Undulate, p. 46.
Unguiculate. Narrowed into a claw or petiole-like base.
Unigeneric. Said of a family composed of a single genus, as Ginkgoaceae.
Unijugate. Said of a compound leaf composed of one pair of leaflets.
Unilocular. Containing a single chamber or "cell."
Units of classification, discussed, pp. 21–24.
Urceolate, p. 64.
Utricle, p. 81.

Vaginate. Sheathed.
Valid Name, p. 90; *valid publication*, p. 92.
Vallecular. Pertaining to the grooves between the ridges, as in fruits of many Umbelliferae.
Valvate. Opening by valves; meeting by the edges without overlapping.
Valve. A separable part of a pod; the units or pieces into which a capsule splits or separates on dehiscing; a flaplike cover or lid as in some stamens.
Variety (varietas), pp. 22, 24, 95–96.
Vascular. Pertaining to the presence of vessels in the conducting tissues of the stele.
Vascular cryptogams, pp. 27–31.

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