PLANT CLASSIFICATION

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Classification

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Principal Plant Dissections and Illustrations

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B O S T O N

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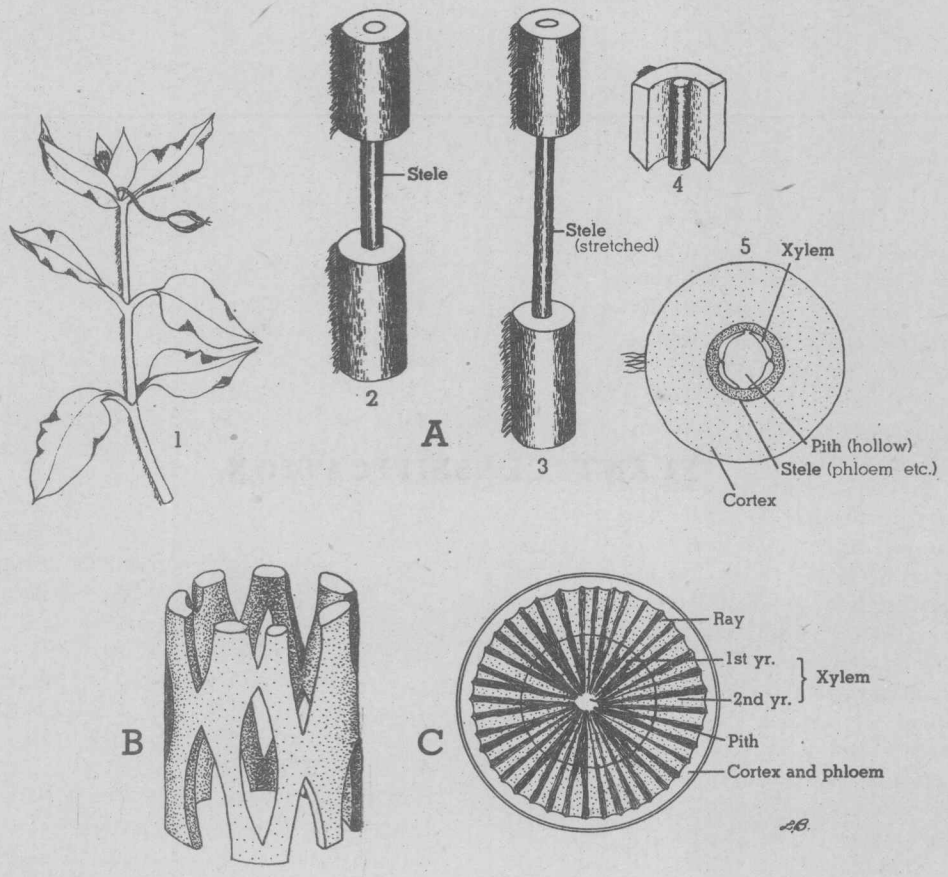

Fig. Int.-1. Vascular tissues (xylem and phloem): **A** chickweed (*Stellaria media*), **1** branch with leaves, a fruit, and a flower, **2** portion of the stem with all but the vascular tissue (stele) removed, **3** the same with the elastic vascular tissues stretched by pulling, **4** portion of the stem with the outer tissues split away, exposing the stele, **5** cross section of the stem; **B** xylem (wood) remaining after decay of the fleshy tissues of a cholla (cylindroidal-stemmed cactus, *Opuntia Parryi*), showing the network formed by the "vascular bundles"; **C** diagrammatic cross section of the woody stem of a two-year-old branch of the coast live oak (*Quercus agrifolia*).

Preface

[TO THE TEACHER]

In the first half of the Twentieth Century plant classification has been modified by data from many sources. Because the factors to be taken into account have changed, the entire field of taxonomy requires redescription and revaluation. Two books on the vascular plants are needed, as follows.

1. *An elementary textbook* intended to open up the new world of living plants to college students and the educated public. The objective is development of a more than superficial appreciation of nature through precise and effective methods of study based upon (1) acquiring for use as a tool an adequate *vocabulary describing the characteristics of each plant group,* (2) applying the use of keys and descriptions to the *process of identification,* (3) gaining knowledge of plant taxa through *preparation and preservation of specimens* forming an ordered collection, (4) developing an understanding of the *basis for classification* of plant groups, (5) gaining an appreciation of the *association of species* in natural vegetation. An introductory book must deal primarily with the higher taxa — that is, the divisions, classes, subclasses, orders, and families.

2. *An advanced textbook* with primary emphasis upon the principles underlying classifying, naming, and describing botanical taxa. Assuming the student has learned the outlines of the higher taxa and something of their classification by studying the elementary book, emphasis falls upon application of principles of taxonomy and nomenclature to genera, species, and varieties. Major items are (1) exploration for data (from field and herbarium studies, microscopic morphology and development, plant physiology and ecology, cytogenetics,* and experimental studies* combining various fields), (2) classification or delimitation of taxa, (3) choice of scientific names, (4) description, and (5) documentation.

Plant Classification is an *elementary text* with the objectives listed above for a book of that scope. It is designed for a college course *without prerequisite.* The earlier chapters are very elementary, the later ones more and more advanced. For courses with a prerequisite of general botany or biology some chapters (e.g., I–V, or XIII) may be omitted or reviewed rapidly.

The Keys and Descriptions. *The keys and descriptions in this book are designed to be followed until the family is determined; then the keys in the local flora or manual should be used to identify the genus and species.* All flowering plant families represented in North America north of Mexico by native or introduced species growing without the intentional aid of man and all gymnosperm and pteridophyte families are covered in the keys. This includes nearly all the families of flowering plants in cultivation. Both these and the remaining flowering plant families are described and discussed.

The keys and descriptions offer the following features differing from those in most manuals and floras.

1. **A simplified vocabulary.** However, the keys and descriptions are complete, and the terms are technical.

* Application of both cytogenetic and experimental investigations to plant taxonomy is restricted so far almost wholly to study of taxa of lower ranks; consequently, these "new methods" are appropriate to only the advanced text.

2. **Arrangement according to a new system of classification,** combining the best features of the older systems with interpretations based upon new data.

3. **Provision of natural keys leading to the orders and then to their included families.** As far as possible the keys are arranged according to natural relationships, and the characters of orders and the distinctions between related families are emphasized. Consequently, the broad outlines of classification are evident and readily remembered. The orders of dicotyledons are arranged in five groups recognized so easily that after identification of a few plants the first divisions of the key may be covered from memory. These features are lost in elongated artificial keys ignoring the orders and segregating the families directly.

The Divisions, Classes, and Subclasses of Vascular Plants. The system of classification of the higher taxa of vascular plants is new, and it includes revisions of taxa at all levels from division to family. The changes from the classical system involve problems of both *classification* and *nomenclature.*

Classification

Because of the accumulation of information accentuating the differences and the gaps between components of certain classical groupings, the major taxa of vascular plants are reclassified as follows.

The Divisions of the Pteridophytes. The four major groups of living pteridophytes are connected more clearly than other high ranking taxa by series of fossil plants. The fern, horsetail, club moss, and *Psilotum* lines of development are plausible series radiating from *Rhynia* or its near relatives among the Devonian Psilophytales and culminating in or near the living plants of each series.

This raises a question of principle in classification – are the limits of taxa to be set in accordance with the past as well as the present? Presumably the divergence of any two taxa from a common ancestor may have occurred as shown by the circles in figure P-1, each successive pair representing the state of isolation of the two taxa in a later geological unit of time. Classification of the taxa indicated by the circles could not be the same for any two long periods. At first they were a single unit, later a less homogeneous unit, then two units difficult to segregate, finally two clearly different units. Presumably this is the course of history of most pairs or groups of taxa. Consequently, their limits must have changed with geologic time, and a classification of present plants must represent them as they are now. Taxa known only from fossils (as for example the orders Hyeniales, Lepidodendrales, and Psilophytales) belonged to the temporary larger units (divisions and classes) of past geologic periods. Fossil records may indicate, as with the pteridophytes, the history and relationships of the living taxa, but they do not bring about the amalgamation or determine the limits of the taxa formed by their modern descendants. The accompanying diagram indicates the known pteridophytes and their possible classification from Silurian and early Devonian time to the present. According to this interpretation the ancient division Psilophyta has

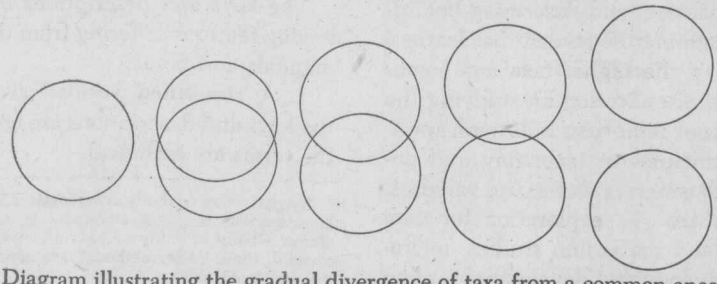

Fig. P-1. Diagram illustrating the gradual divergence of taxa from a common ancestor.

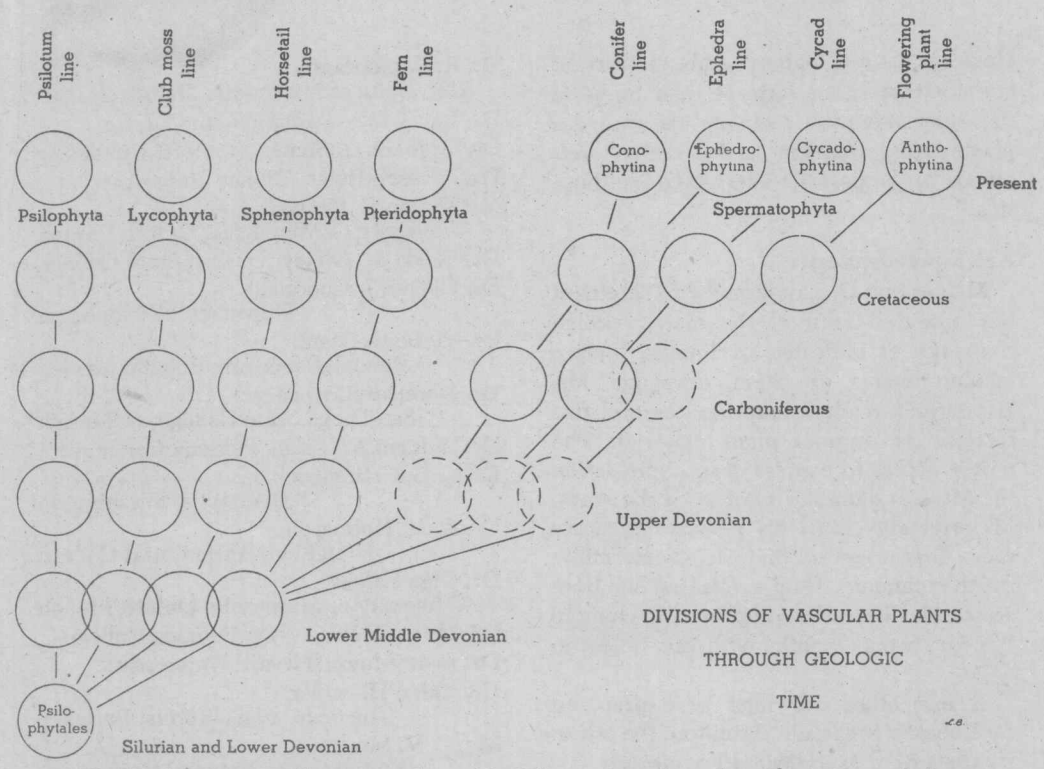

Fig. P-2. Diagram illustrating the gradual divergence through geologic time of the divisions and subdivisions of the vascular plants.

become divided into four modern divisions.

In this instance connecting series of fossils are known; in others they are not, probably being rare or nonexistent because the plants either (1) did not grow in marshes or other places favorable to formation of fossils or (2) lacked hard parts readily fossilized.

The Classes of the Spermatophytes. The flowering plant, conifer, *Ephedra, Gnetum,* and cycad lines of development evidently were not derived one from another, but they are separate series from a more remote common ancestry than has been supposed. The differences and the gaps between any two of the last four (gymnosperm) lines appear to be nearly as great as those between any of these and the flowering plants.

All five lines of spermatophytes are of remote and unestablished origin. The conifer and cycad lines have been distinct at least since Carboniferous time and probably since the middle part of the Devonian Period. The origins of the *Ephedra, Gnetum,* and the angiosperm lines in Mesozoic or perhaps Paleozoic time are not known from fossils. Probably all five lines of development were derived from early members of the fern line, but data are incomplete.

According to one point of view the fern division should be enlarged to include both the Pteridophyta and the Spermatophyta (as described here). In early geologic time doubtless this line of development constituted a division, but it has divided into two modern units as significant and clearly distinct as each of the three other entire surviving lines of development from the Psilophytales.

Nomenclature

In general the names of the taxa have been adjusted to correspond with Recommendation 26A of the International Code of Botanical Nomenclature adopted at Stockholm in 1950 and published in 1952.

However, a few names seem to warrant conservation in the form of their usage in the older literature. Among the vascular plants "Angiospermae" is retained in preference to the possible alternative "Anthopsida."

Acknowledgments

Mr. Jerome D. Laudermilk of Claremont has prepared most of the more detailed drawings, as indicated by initials. Before making many of these drawings Mr. Laudermilk made minute and careful dissections of original plant material. The writer wishes to express deep appreciation for Mr. Laudermilk's interest in the work, his originality, and his painstaking accuracy. It is regretted that Mr. Laudermilk's death in January, 1956, prevented him from seeing his illustrations in print. He clung to life for several months with this object in view.

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Introduction

In the 1880's the Apaches were on the warpath. No white man in the vast network of mountains and high plains of Arizona and New Mexico was safe. Even the lowland cities like Phoenix and Tucson were under military protection.

Two botanists, Mr. and Mrs. J. G. Lemmon of Berkeley, California, wished to collect plants in the Huachuca Mountains in the heart of the Apache country. They rode southeastward from Tucson a day's journey, expecting to spend the night at the ranch of some friends, but the house had been burned and the settlers scalped. And so the Lemmons camped overnight, and the next day they went on toward the Huachuca Mountains, planning to spend the night with friends at a ranch farther on. But these friends had been scalped. And so the Lemmons camped again, and the next day they went on toward the Huachuca Mountains.

Soon they met a small band of Apaches in war paint. The Lemmons were stopped and searched; the plant presses were opened and the specimens examined. Finally the chief came up with the main band of Apaches. He inspected the plant presses gravely, then tapped his forehead. And so the Lemmons went on to the Huachuca Mountains.

If plant collecting is a form of insanity, it is a mild and pleasant one associated with a love of the out-of-doors, fascination with the infinite variety of patterns of plant characteristics, and the challenge of problems arising from their study. The beginning is like solving puzzles – determining the identity of each unknown plant by a process of elimination. Choice after choice is made in a key between alternative characteristics, only one of which is present in the plant in question. Finally, if every decision is correct, the identity of the plant is learned.

As the vocabulary describing the characteristics of a plant group becomes better known, as *the process of identification* becomes easier, and as the *preparation and preservation of specimens* result in an orderly collection, the chief center of interest shifts from these primarily mechanical processes to *the basis for classification.* Many plants are seen to have characters in common yet to differ in varying degrees from each other, and new problems arising from the complexities of classification gradually replace the gamelike process of identification. Ultimately classification of plants results in yet another field of interest – the *association of species* in the natural vegetation of the region.

Units of the Plant Kingdom

Plant identification is an orderly process resulting in assignment of each individual to a descending series of groups of related plants, as judged by characteristics in common. A rose is placed first among the plants with seeds, then among the seed plants having flowers, and so on through subordinate group after group until it is associated finally with its nearest relatives – the other kinds of roses.

The Plant Kingdom is made up of classically recognized major groups as follows.

The Vascular Plants (*or Tracheophytes*). These include the flowering plants, as illustrated by many figures in especially Chapters X and XI; the gymnosperms (e.g., pines, firs, etc.), as illustrated in Chapters XVIII to XX; and the pteridophytes (the ferns and other spore-producing plants), as illustrated in Chapters XXI to XXIII. Parts are illustrated in Chapters II–IX.

The Mosses and Liverworts. The mosses in particular are common chiefly in moist places, including the shady sides of rocks and trees, and the liverworts occur mostly in similar situations, though often on moist soil.

The Algae and Fungi. The algae include the seaweeds and the common essentially microscopic algae or pond scums, which to the naked eye may resemble green hairs. Examples of the fungi are mushrooms and bread mold.

This book is concerned with only the vascular plants, that is, the flowering plants, gymnosperms, and pteridophytes. These are the large plants of the Earth. Their bodies are differentiated into stems, leaves, and roots, and internally these organs contain **vascular** (conducting) **tissues** known technically as xylem and phloem. In older stems of trees the *xylem and associated tissues* occur as a thick inner cylinder of wood surrounding a small cylinder of pith; the *phloem and associated tissues* form a thin outer hollow cylinder of bark surrounding the wood. In young stems and in older plants which are not markedly woody, these tissues form an internal network within the stem; and the strands of the network are spoken of as "vascular bundles." Vascular traces from the stem lead to the veins of the leaves. Young roots contain a solid core of xylem and phloem. The vascular plants are the only ones in the Plant Kingdom having xylem and phloem.

The vascular plants include the five **divisions** listed below:

Spermatophyta or **Seed Plants.** Literally "seed plants."

Pteridophyta or **Ferns.** Literally "fern plants."

Sphenophyta or **Horsetails.** The technical name means "wedge plants." It is based upon *Sphenophyllum* ("wedge-leaf"), an extinct plant known only from fossils.

Lycophyta or **Club Mosses.** The technical name means "wolf plant." It is based upon *Lycopodium,* club moss, or literally "wolf-foot," derived from a fancied resemblance to a wolf's foot or track.

Psilophyta. The name is derived from that of *Psilotum,* a largely tropical plant with no leaves, i. e., with bare branches.

Each division of the vascular plants is composed of subordinate groups (**taxa**—singular **taxon**). Arranged in order of rank, these are as follows: class, order, family, genus, species, and variety.

Division	*Class*	*English Name*	*Group Name*
Spermatophyta	Angiospermae (covered seeds)		
	Subclass Dicotyledoneae (2 seed leaves)	Dicotyledons	Flowering Plants
	Subclass Monocotyledoneae (1 seed leaf)	Monocotyledons	Flowering Plants
	Conopsida (cone)	Conifers	Gymnosperms
	Ephedropsida (*Ephedra*)	*Ephedra*	Gymnosperms
	Gnetopsida (*Gnetum*)	*Gnetum, Welwitschia*	Gymnosperms
	Cycadopsida (cycad)	Cycads	Gymnosperms
Pteridophyta	Pteropsida (feather)	Ferns	Pteridophytes
Sphenophyta	Sphenopsida (wedge)	Horsetails	Pteridophytes
Lycophyta	Lycopsida (wolf)	Club mosses	Pteridophytes
Psilophyta	Psilopsida (bareness)	*Psilotum,* etc.	Pteridophytes

NOTE: The ending *-opsida* for classes means "with the appearance of" the object or quality in parentheses.

The divisions of vascular plants are composed of the following classes and (in the flowering plants) subclasses:

The Angiospermae are composed of two subclasses: (1) the Dicotyledoneae (dicotyledons or dicots), the larger group including, for example, the broad-leaved trees, roses, peas, sunflowers, and buttercups; and (2) the Monocotyledoneae (monocotyledons or monocots), including, for example, the grasses, lilies, orchids, irises, palms, and cannas. The Dicotyledoneae include fifty-six **orders.** One of these is the Rosales (rose order), which includes a number of **families,** among them the rose, pea, saxifrage, stonecrop, and witch-hazel families. A family is composed of one or more **genera** (singular **genus** — from the same Latin origin as general). In the rose family (Rosaceae) an example is the genus *Rosa,* which includes all the roses. Each genus is made up of **species** (singular as well as plural — from the same Latin origin as specific), such as *Rosa setigera,* climbing rose. The basic **name** of the plant is a combination of a word designating the genus with a word designating the species. Species are made up of **varieties.*** The name of one of these repeats the designation of the species, e.g., *Rosa setigera* var. *setigera,* but often this is omitted because it is considered to be understood. The other varieties have epithets (adjectives used as nouns) similar to those of species, e.g., *Rosa setigera* var. *tomentosa.* The botanical variety is not to be confused with the horticultural "variety," which is not a taxon but a minor variant or hybrid of economic or aesthetic significance.

The term subspecies is used by some authors in exactly the same sense as variety. Others employ it as a designation for a group of higher rank than variety but lower than species. The majority of botanists have not used the term, but it is in common usage in zoölogy. The arguments for or against its use in botany are relatively complex, and the uniform use of one category or the other would outweigh the advantages of either. A taxon of lower rank than variety is forma. It is used by some authors but not by others.

To summarize, the list of categories (taxa) is as follows:

Taxon	*Example*	*English Name*
Division	Spermatophyta	Seed plants
Class	Angiospermae	Flowering plants
Subclass	Dicotyledoneae	Dicots
Order	Rosales	Rose order
Family	Rosaceae	Rose family
Genus	Rosa	Rose
Species	*setigera	Wild climbing rose
Variety	tomentosa	A special climbing rose

Pronunciation of scientific names may be either Latinized or Anglicized. Few American botanists use a "Latin" pronunciation. Unfortunately, agreement upon English pronunciation is by no means complete.

Placing of the accent in the names of orders and families follows a simple rule. It is on the first syllable of the termination, "-ales" (pronounced ā′lēs) for order and "-aceae" (pronounced ā′sē-ē) for family. Thus it is (Rosā′les, Ranā′les, Rhamnā′les, etc., and Rosā′ceae, Ranunculā′ceae, Rhamnā′ceae, etc.

* **Variety** is the singular of the English word, but, strictly speaking, according to the International Code of Botanical Nomenclature, the botanical word is not *variety* but **varietas.**

* Specific "names" (epithets) formed from those of persons or deities or the adopted names of genera or aboriginal names used for species may be capitalized or, according to preference, all specific epithets may be decapitalized.

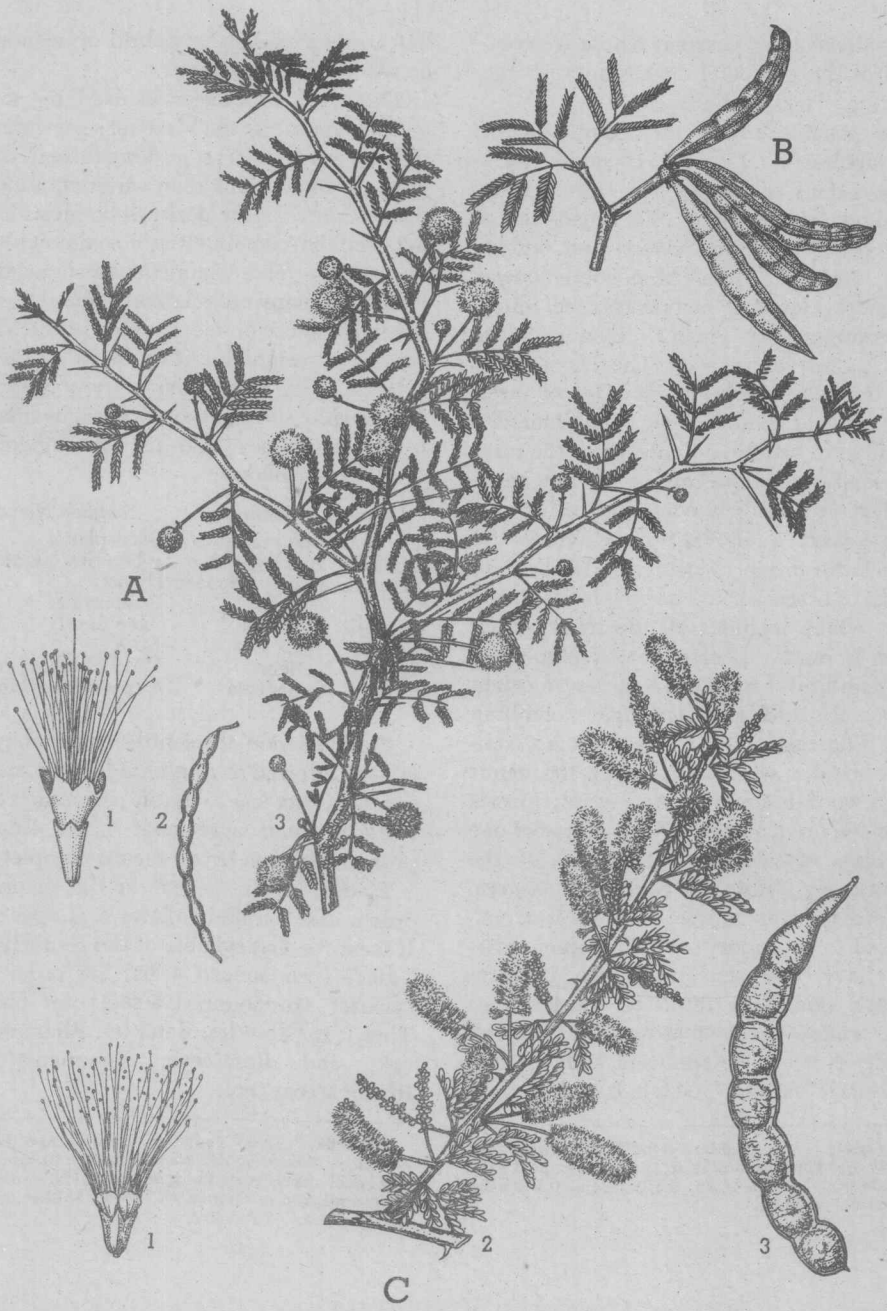

Fig. I-1. Thorny acacias of the Southwestern Deserts: **A** white thorn (*Acacia constricta*), 1 flower, 2 fruit (pod or legume), 3 flowering branch showing the pairs of spines at the nodes (joints) of the stem; **B** huisache (*Acacia Farnesiana*), fruiting branch; **C** cat-claw (*Acacia Greggii*), 1 flower, 2 flowering branch showing the prickles irregularly arranged along the stem, 3 fruit. From LYMAN BENSON and ROBERT A. DARROW. *The Trees and Shrubs of the Southwestern Deserts. Ed. 2.* Courtesy of the University of Arizona and University of New Mexico presses.