

Classification, Evolution, and Phylogeny of the Families of Dicotyledons

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ABSTRACT

Goldberg, Aaron. Classification, Evolution, and Phylogeny of the Families of Dicotyledons. *Smithsonian Contributions to Botany*, number 58, 314 pages, 164 figures, 2 tables, 1986. To some extent classification is subjective. Taxonomists differ in the relative importance they ascribe to particular characters and in the degree of difference between related taxa they deem sufficient to constitute family or ordinal rank. About 1000 dicot family names have been published. Those who have attempted an overview of the system at the family level and above in the last quarter century recognize between 274 and 455 dicot families in 39 to 82 orders. I accept 334 families and 59 orders. In Table 1 I give my ordinal allocation of the families and that of 11 recent authors to indicate where there is agreement and where there are differences to be resolved. I have also constructed a dendrogram to suggest relationships and degree of advancement of the orders.

I have written concise, uniform descriptions of all the families of dicots, emphasizing those characters that show trends between families or occur in more than one family. Each family is illustrated by analytical drawings of the flower, fruit, seed and usually inflorescence. Several species are usually used to show the range of major variation within families and trends toward related families.

Angiosperms probably arose from gymnosperms, so characters or character states universal in gymnosperms or considered primitive in them would also be considered primitive in angiosperms.

My approach to understanding evolutionary trends in characters is to relate them to the ecological factors that might be responsible for them by their selective action. The dicots probably originated under warm temperate conditions favorable for growth. A major evolutionary trend in them has been the gradual development of characters and character states enabling them to cope with dry and hot or cold conditions and colonize generally unfavorable regions.

A second major trend has been from wind pollination to progressively better adaptation for insect pollination. The primitive insect pollinated dicots often have flowers with numerous spirally arranged parts; plants having flowers with few, opposite or whorled parts are derived.

The floral organs are homologous with leaves. Like leaves the parts were initially separate. The connate and adnate conditions are derived.

General character states are primitive; specialized states are derived. In attempting to determine which primitive states are most primitive I considered their occurrence among the families. The fewer the families with a particular primitive state, the more primitive the state. This is important in deciding whether a family is low or high on the family tree and the position within its particular order.

In accordance with the above rationale, I have constructed a table giving the primitive and derived states for about 100 characters. I also indicate the extent to which I consider the states reversible.

To determine a family's phylogeny, it must be compared with other families considered to be close to it. In general, the more characters and character states in common, particularly uncommon ones, the more likely are the subject families to be related. All parts of the plant and many characters should be considered. If a family has more than one state of a character, the state considered primitive for the particular taxon rather than the derived one should be considered in attempting to determine the extant family closest to its ancestor. A descendant has at least one more derived character or character state than its ancestor.

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Introduction

To some extent classification is subjective. Taxonomists differ in the relative importance they ascribe to particular characters and in the degree of difference between related taxa they deem sufficient to constitute family or ordinal rank. About 1000 dicot family names have been published. Those who have attempted an overview of the system at the family level and above in the last quarter century recognize between 274 and 455 dicot families in 39 to 82 orders. I accept 334 families and 59 orders. About 76% of the dicot families and 76% of the orders I accept were recognized before 1875, the publication date of Eichler's system, the first in which the concept of evolution was accepted. Of course, the circumscription of some families and orders has been changed since 1875. About 1.5% of the dicot families and orders were published in the last quarter century.

In delimiting families and assigning them to orders I rely on many years of study in the National Herbarium and library of the Smithsonian Institution as well as examination of plants in the field and at botanical gardens in various parts of the world. I have examined numerous

specimens in all families except three monotypic ones.

I have written concise, uniform descriptions of all the families of dicots, emphasizing those characters that show trends between families or occur in more than one family. Each family is illustrated by analytical drawings of the flower, fruit, seed, and usually inflorescence. The illustrations have been reproduced as economically as possible for the purpose of illustrating major features; no attempt has been made to represent the fine detail that would be expected in traditional taxonomic studies published in *Smithsonian Contributions to Botany*. Abbreviations used in the legends are as follows: l.s. = longitudinal section; c.s. = cross section.

I deeply appreciate the permission granted by the Oxford University Press to use many illustrations from their publication (J. Hutchinson, 1973), and also permission of colleagues to use illustrations from their publications, and also their help in other ways.

At present the only work in English describing and illustrating all the dicot families in a single volume is Hutchinson's *The Families of Flowering Plants* (1973). I believe Hutchinson's theory of relationships places undue emphasis on whether the families are primarily woody or herbaceous. Also, his concept of families is narrower than mine. Usually he illustrates each family by a

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single species whereas I usually use several species to show the range of major variation within families, and sometimes the species illustrated show trends toward related families. He illustrates sections of seeds showing the embryo for half the families whereas I do so for most families. He illustrates leaves more frequently than I do.

Perusal of the references dealing with chemotaxonomy indicates how little is known for many of the families, so I did not consider chemical data under the family descriptions. However, I have discussed under each order those chemical data I consider most significant in understanding relationships of the families, orders, and sometimes genera. I have not included data on chromosome numbers because, although they are significant in indicating relationships within families, it has not been determined whether this character is appreciably useful to show relationships between families.

In Table 1 I give my ordinal allocation of the families and that of 11 authors who have attempted an overview of the system in the last quarter century to indicate where there is agreement and where there are differences to be resolved. In my decisions I have also considered the opinions of 17 earlier generalists, starting with Bentham and Hooker, as well as those of authors who have studied particular families.

The bibliography mentions publications of several authors who have attempted to improve the system of classification of the dicots at the family level and above in the 19th and 20th centuries. It also mentions authors who have assembled the data dealing with particular characters for most families. Together, these publications contain references to the work of thousands of scientists who have made contributions in particular families. Stafleu and Cowan and the Kew Record of Taxonomic Literature can also be consulted for relevant literature. In the figure legends, all authors cited without publication dates are to be found in Stapf (1929–1931).

Jackson (1928) and Lawrence (1951) can be used to determine the meaning of botanical terms. I use the term pistil to mean a separate

female organ. It can consist of one or more carpels. The gynoecium may consist of one or more pistils.

Angiosperms probably arose from gymnosperms, so characters or character states occurring universally in gymnosperms or considered primitive in them would also be considered primitive in angiosperms. Gymnosperms are dioecious or monoecious. Xylem vessels are almost universally lacking. The reproductive organs are not subtended by a perianth. When the pollen grains are aperturate, they are monosulcate.

Since gymnosperms are almost universally wind-pollinated, the earliest angiosperms must have been wind-pollinated, and since gymnosperms with this characteristic have survived, I see no reason why primitive wind-pollinated angiosperms could not have survived. Engler and his followers begin the system with the *Casuarinaceae* and *amentiferae*. However, there are wind-pollinated dicots that have more primitive character states than those groups. For example, *Tetracentron* (*Tetracentraceae*) and *Sarcandra* (*Chloranthaceae*) have vesselless wood, whereas *Casuarina* and the *amentiferae* have vessels. The carpels are connate in *Casuarina* and the *amentiferae*; they are separate in *Cercidiphyllum* (*Cercidiphyllaceae*). The *amentiferae* frequently have an inferior ovary, whereas it is superior in the more primitive, wind-pollinated families. The pollen grains are sometimes monosulcate in *Chloranthaceae*, but never in *Casuarina* and the *amentiferae*. In *Casuarina* and the *amentiferae* storage food of the seed is restricted to the embryo, whereas in the gymnosperms and more primitive, wind-pollinated dicots much of it is outside the embryo. Also, these systems give greater weight to the sympetalous state than I do, dividing the dicots into subclasses *Archichlamydeae* and *Sympetalae*. Most of the other systems begin with the *Magnoliales*, but these too show evidence of their anemophilous ancestry in having pistils with a large stigmatic surface and numerous stamens with abundant pollen.

My approach to understanding evolutionary trends in characters is to relate them to the

ecological factors that might be responsible for them by their selective action. A major evolutionary trend has been from wind pollination to progressively better adaptation for insect pollination. Under favorable conditions where most families can survive and members of a species are often widely spaced, insect pollination is more proficient than wind pollination. Many plants developed colorful flowers or bracts, making the flowers easier for insects or other animals to find. Some flowers became fragrant or malodorous, indicating the presence of food to potential pollinators. Some produced nectar that may act as a substitute reward in place of reproductive organs. Access to the reward became more and more restricted, favoring insects with long sucking mouth parts. Some flowers became more specially adapted to the most proficient pollinators, the bees.

The primitive, insect-pollinated dicots often have large flowers with numerous spirally arranged parts. They gave rise to plants whose flowers have few, opposite, or whorled parts. The proficiency of insects in pollination allows survival with fewer parts. Under harsher conditions, where fewer taxa can survive, some insect-pollinated plants became gregarious and secondarily wind-pollinated. They also have small flowers with few parts.

The dicots probably originated under warm temperate conditions favorable for growth. Another major evolutionary trend in them has been the gradual development of characters and character states enabling them to cope with dry and hot or cold conditions, allowing them to colonize generally unfavorable regions.

By reduction of internodes and modification of leaves, the flowers developed a calyx that provides some protection of the reproductive organs against unfavorable climatic conditions, as well as enabling them to avoid some predators. Development of perigyny and epigyny also conserved moisture in the reproductive organs. The leaves evolved various conditions of the cuticle, epidermis, and vasculature that enable them to resist moisture loss and prevent collapse. Also, in

the xylem, tracheids were converted to vessels and scalariform perforation plates became simple and the vessels wider to facilitate rapid movement of water, which is only periodically available under unfavorable conditions.

The floral organs are homologous with leaves. Like leaves, the parts were initially separate. The connate and adnate conditions are derived.

General character states are primitive; specialized states are derived. In attempting to determine which primitive states are most primitive I considered their occurrence among the families. The fewer the families showing a particular primitive state the more primitive the state. For example, very few families still have vesselless wood, so I consider that condition one of the most primitive of the primitive states. This is important in deciding whether a family is low or high on the family tree and the position within its particular order.

In accordance with the above rationale, I have constructed Table 2, giving the primitive and derived states for about 100 characters. I also indicate the extent to which I consider the states reversible. In general, character states that are most constant within families are least readily reversed. For example, flower color is usually variable within families and commonly reversible, whereas cotyledon number is almost invariably constant within families and therefore difficult to reverse. The category "n" includes those character states that are practically irreversible.

To determine a family's phylogeny, it must be compared with other families considered to be close to it. In general, the more characters and character states in common, particularly uncommon ones, the more likely are the subject families to be related. All parts of the plant and many characters should be considered.

I agree with those who make a distinction between parallelism and convergence. The same character or character state may arise more than once in a single family or independently in related families. That is parallelism. If the same character or character state arises in unrelated families it is convergence. Unrelated taxa with

TABLE 1.—Ordinal allocation of dicotyledon families by recent authors.

Family	Goldberg	Cronquist 1981	Takhtajan 1983	Thorne 1983	Dahlgren 1983	Emberger 1960
Cercidiphyll	Trochodendr	Hamamelid	Cercidiphyll	Hamamelid Trochodendrineae	Cercidiphyll	Polycarpicae
Tetracentr	Trochodendr	Trochodendr	Trochodendr	Hamamelid Trochodendrineae	Trochodendr	Polycarpicae
Euptele	Trochodendr	Hamamelid	Euptele	Hamamelid Trochodendrineae	Cercidiphyll	Polycarpicae
Trochodendr	Trochodendr	Trochodendr	Trochodendr	Hamamelid Trochodendrineae	Trochodendr	Polycarpicae
Platan	Hamamelid	Hamamelid	Hamamelid Hamamelidinae	Hamamelid Hamamelidinae	Hamamelid	Ros
Myrothamn	Hamamelid	Hamamelid	Hamamelid Hamamelidinae	Pittospor Brunineae	Hamamelid	Ros
Bux	Hamamelid	Euphorbi	Hamamelid Buxineae	Pittospor Buxineae	Bux	Terebinth
Hamamelid	Hamamelid	Hamamelid	Hamamelid Hamamelidinae	Hamamelid Hamamelidinae	Hamamelid	Ros
Daphniphyll	Hamamelid	Daphniphyll	Hamamelid Hamamelidinae	Pittospor Buxineae	Bux	Euphorbi
Didymel	Hamamelid	Didymel	Didymel	Pittospor Buxineae	Bux	Leitneri
Magnoli	Magnoli	Magnoli	Magnoli Magnoliineae	Annon Annonineae	Magnoli	Polycarpicae
Winter	Magnoli	Magnoli	Magnoli Winterineae	Annon Winterineae	Magnoli	Polycarpicae
Annon	Magnoli	Magnoli	Magnoli Annonineae	Annon Annonineae	Annon	Polycarpicae
Degeneri	Magnoli	Magnoli	Magnoli Magnoliineae	Annon Annonineae	Magnoli	Polycarpicae
Austrobailey	Magnoli	Magnoli	Laur Monimiineae	Annon Annonineae	Annon	Polycarpicae
Himantandr	Magnoli	Magnoli	Magnoli Magnoliineae	Annon Annonineae	Magnoli	Polycarpicae
Eupomati	Magnoli	Magnoli	Magnoli Magnoliineae	Annon Annonineae	Annon	Polycarpicae
Myristic	Magnoli	Magnoli	Magnoli Annonineae	Annon Annonineae	Annon	Polycarpicae
Canell	Magnoli	Magnoli	Magnoli Annonineae	Annon Annonineae	Annon	Polycarpicae
Schisandr	Magnoli	Illici	Illici	Annon Illiciineae	Illici	Polycarpicae
Illici	Magnoli	Illici	Illici	Annon Illiciineae	Illici	in Winteraceae
Amborell	Magnoli	Laur	Laur Monimiineae	Annon Laurineae	Laur	in Monimiaceae
Trimeni	Magnoli	Laur	Laur Monimiineae	Annon Laurineae	Laur	in Monimiaceae
Monimi	Magnoli	Laur	Laur Monimiineae	Annon Laurineae	Laur	Polycarpicae
Idiosperm	Magnoli	Laur	in Calycanthac	in Calycanthaceae	in Calycanthaceae	—
Calycanth	Magnoli	Laur	Laur Monimiineae	Annon Laurineae	Laur	Polycarpicae
Gomorteg	Laur	Laur	Laur Monimiineae	Annon Laurineae	Laur	Polycarpicae
Laur	Laur	Laur	Laur Laurineae	Annon Laurineae	Laur	Polycarpicae
Hernandi	Laur	Laur	Laur Laurineae	Annon Laurineae	in Lauraceae	Polycarpicae
Aristolochi	Aristolochi	Aristolochi	Aristolochi	Annon Aristolochiineae	Aristolochi	Aristolochi
Menisperm	Ranuncul	Ranuncul	Ranuncul	Berberid Berberidineae	Ranuncul	Polycarpicae

TABLE 1.—continued.

Family	Hutchinson 1973	Melchior 1964	Stebbins 1974	Rouleau 1981	Young 1981	Benson 1979
Cercidiphyll	Magnoli	Magnoli	Hamamelid	Cercidiphyll	Trochodendr	Hamamelid Trochodendrineae
Tetracentr	Hamamelid	Magnoli	Trochodendr	Trochodendr	Trochodendr	Hamamelid Trochodendrineae
Euptele	in Trochodendra	Magnoli	Hamamelid	Euptele	Trochodendr	Hamamelid Trochodendrineae
Trochodendr	Magnoli	Magnoli	Trochodendr	Trochodendr	Trochodendr	Hamamelid Trochodendrineae
Platan	Hamamelid	Ros Hamamelidinae	Hamamelid	Hamamelid	Hamamelid	Hamamelid Hamamelidinae
Myrothamn	Hamamelid	Ros Hamamelidinae	Hamamelid	Hamamelid	Myrothamn	Ros
Bux	Hamamelid	Celastr Buxineae	Euphorbi	Euphorbi	Bux	Euphorbi
Hamamelid	Hamamelid	Ros Hamamelidinae	Hamamelid	Hamamelid	Hamamelid	Hamamelid Hamamelidinae
Daphniphyll	Hamamelid	Gerani Euphorbiinae	Euphorbi	Euphorbi	Bux	?
Didymel	Bix	Leitneri	Hamamelid	Didymel	Euphorbi	?
Magnoli	Magnoli	Magnoli	Magnoli	Magnoli	Magnoli	Ran Magnoliinae
Winter	Magnoli	Magnoli	Magnoli	Magnoli	Magnoli	Ran Magnoliinae
Annon	Annon	Magnoli	Magnoli	Magnoli	Magnoli	Ran Magnoliinae
Degeneri	in Winteraceae	Magnoli	Magnoli	Magnoli	Degeneri	Ran Magnoliinae
Austrobailey	Laur	Magnoli	Laur	Laur	Illici	Ran Laurineae
Himantandr	Magnoli	Magnoli	Magnoli	Magnoli	Aristolochi	Ran Magnoliinae
Eupomati	Annon	Magnoli	Laur	Magnoli	Magnoli	Ran Magnoliinae
Myristic	Laur	Magnoli	Magnoli	Magnoli	Aristolochi	Ran Magnoliinae
Canell	Magnoli	Magnoli	Magnoli	Magnoli	Magnoli	Ran Laurineae
Schisandr	Magnoli	Magnoli	Illici	Illici	Illici	Ran Magnoliinae
Illici	Magnoli	Magnoli	Illici	Illici	Illici	Ran Magnoliinae
Amborell	in Monimiaceae	Magnoli	Laur	Laur	Laur	Ran Laurineae
Trimeni	Laur	Magnoli	Laur	Laur	Laur	Ran Laurineae
Monini	Laur	Magnoli	Laur	Laur	Laur	Ran Laurineae
Idiosperm	Ros	—	—	Laur	Laur	—
Calycanth	Ros	Magnoli	Laur	Laur	Laur	Ran Laurineae
Gomorteg	Laur	Magnoli	Laur	Laur	Laur	Ran Laurineae
Laur	Laur	Magnoli	Laur	Laur	Laur	Ran Laurineae
Hernandi	Laur	Magnoli	Laur	Laur	Laur	Ran Laurineae
Aristolochi	Aristolochi	Aristolochi	Aristolochi	Aristolochi	Aristolochi	Aristolochi
Menisperm	Berberid	Ranuncul	Ranuncul	Ranuncul	Ranuncul	Ran Ranunculinae

TABLE 1.—continued.

Family	Goldberg	Cronquist 1981	Takhtajan 1983	Thorne 1983	Dahlgren 1983	Emberger 1960
Sargentodox	Ranuncul	Ranuncul	Ranuncul	Berberid Berberidinaeae	Ranuncul	Polycarpicae
Lardizabal	Ranuncul	Ranuncul	Ranuncul	Berberid Berberidinaeae	Ranuncul	Polycarpicae
Nandin	Ranuncul	in Berberidaceae	in Berberidaceae	Berberid Berberidinaeae	in Berberidaceae	in Berberidaceae
Berberid	Ranuncul	Ranuncul	Ranuncul	Berberid Berberidinaeae	Ranuncul	Polycarpicae
Podophyll	Ranuncul	in Berberidaceae	in Berberidaceae	in Berberidaceae	in Berberidaceae	in Berberidaceae
Paeoni	Ranuncul	Dilleni	Paeoni	Paeoni	Paeoni	in Berberidaceae
Ranuncul	Ranuncul	Ranuncul	Ranuncul	Berberid Berberidinaeae	Ranuncul	Polycarpicae
Circaeaster	Ranuncul	Ranuncul	Ranuncul	Berberid Berberidinaeae	Ranuncul	Polycarpicae
Halorag	Halorag	Halorag	Myrt Haloragineae	Corn Haloragineae	Halorag	Myrt
Gunner	Halorag	Halorag	Saxifrag? Saxifragineae	Corn Haloragineae	Gunner	Myrt
Hippurid	Halorag	Callitrich	Scrophulari Hippurineae	Corn Haloragineae	Hippurid	Myrt?
Callitrich	Halorag	Callitrich	Lami	Lami	Lami	Myrt?
Sarraceni	Sarraceni	Nepenth	Sarraceni	The Sarraceniinaeae	Sarraceni	Sarraceni
Nepenth	Nepenth	Nepenth	Nepenth	The Nepenthineae	The	Sarraceni
Saurur	Piper	Piper	Piper	Annon Piperineae	Piper	Piper
Piper	Piper	Piper	Piper	Annon Piperineae	Piper	Piper
Lactorid	Piper	Magnoli	Laur Lactoridinaeae	Annon Laurineae	Lactorid	Polycarpicae
Chloranth	Piper	Piper	Laur Chloranthineae	Annon Laurineae	Chloranth	Piper
Ceratophyll	Nymphae	Nymphae	Nymphae Ceratophyllinaeae	Nelumbon	Nymphae	Polycarpicae
Cabomb	Nymphae	Nymphae	Nymphae Nymphaeinaeae	Nymphae	Nymphae	Polycarpicae
Nymphae	Nymphae	Nymphae	Nymphae Nymphaeinaeae	Nymphae	Nymphae	Polycarpicae
Nelumbon	Nymphae	Nymphae	Nelumbon	Nelumbon	Nelumbon	in Nymphaeaceae
Prote	Prote	Prote	Prote	Prote	Prote	Prote
Balanop	Balanop	Fag	Balanop	Pittospor Buxineae	Balanop	Balanop
Simmondsi	Fag	Euphorbi	Hamamelid Buxineae	Euphorbi	Euphorbi	in Buxaceae
Leitneri	Fag	Leitneri	Leitneri	Rut Rutineae	Sapind or Rut	Leitneri
Myric	Fag	Myric	Myric	Rut Myricineae	Myric	Myric
Jugland	Fag	Jugland	Jugland	Rut Juglandinaeae	Jugland	Jugland
Rhoiptele	Fag	Jugland	Jugland	Rut Juglandinaeae	Jugland	Urtic or Jugland
Fag	Fag	Fag	Fag	Fag	Fag	Fag
Betul	Fag	Fag	Fag	Fag	Fag	Fag
Salic	Salic	Salic	Salic	Viol Salicineae	Salic	Salic
Casuarin	Casuarin	Casuarin	Casuarin	Casuarin	Casuarin	Casuarin
Eucommi	Urtic	Eucommi	Eucommi	Hamamelid Eucommiinaeae	Eucommi	Urtic

Table 1.—continued.

Family	Hutchinson 1973	Melchior 1964	Stebbins 1974	Rouleau 1981	Young 1981	Benson 1979
Sargentodox	Berberid	Ranuncul	—	Ranuncul	Ranuncul	—
Lardizabal	Berberid	Ranuncul	Ranuncul	Ranuncul	Ranuncul	Ran Ranunculineae
Nandin	Berberid	in Berberidac	—	Ranuncul	Ranuncul	—
Berberid	Berberid	Ranuncul	Ranuncul	Ranuncul	Ranuncul	Ran Ranunculineae
Podophyll	Ran	in Berberidac	—	Ranuncul	Ranuncul	—
Paeoni	Ran	Guttifer	Dilleni	Paeoni	Ranuncul	Dilleni
Ranuncul	Ran	Ranuncul	Ranuncul	Ranuncul	Ranuncul	Ran Ranunculineae
Circaeaster	Berberid	in Ranunculac	Ranuncul	Ranuncul	Ranuncul	—
Halorag	Onagr	Myrt	Halorag	Hippurid	Halorag	Myrt
Gunner	in Haloragaceae	Myrtineae in Haloragaceae	Halorag	Hippurid	Halorag	in Haloragaceae
Hippurid	in Haloragaceae	Myrt Hippuridinae	Halorag	Hippurid	Hippurid	Myrt
Callitrich	Onagr	Tubiflorae Verbeninae	Lami	Lami	Lami	Lami
Sarraceni	Sarraceni	Sarraceni	Sarraceni	Sarraceni	Sarraceni	Sarraceni
Nepenth	Aristolochi	Sarraceni	Aristolochi?	Nepenth	Nepenth	The
Saurur	Piper	Piper	Piper	Piper	Aristolochi	Piper
Piper	Piper	Piper	Piper	Piper	Aristolochi	Piper
Lactorid	Magnoli	Piper	Laur	Laur	Laur	Ran Laurineae
Chloranth	Piper	Piper	Laur?	Laur	Laur	Ran Laurineae
Ceratophyll	Ran	Ranuncul	Nymphae	Nymphae	Ranuncul	Nymphae
Cabomb	Ran	in Nymphaeaceae	—	Nymphae	Nymphae	—
Nymphae	Ran	Ranuncul	Nymphae	Nymphae	Nymphae	Nymphae
Nelumbon	in Nymphaeaceae	in Nymphaeaceae	Nymphae	Nelumbon	Illici	in Nymphaeaceae
Prote	Prote	Prote	Prote	Prote	Prote	Prote
Balanop	Balanop	Balanop	Fag	Balanop	Balanop	?
Simmondsi	in Buxaceae	in Buxaceae	—	Euphorbi	Euphorbi	Euphorbi
Leitneri	Leitneri	Leitneri	Leitneri	Leitneri	Rut	Leitneri
Myric	Myric	Jugland	Myric	Myric	Myric	Myric
Jugland	Jugland	Jugland	Jugland	Jugland	Jugland	Jugland
Rhoiptele	Jugland	Urtic	Jugland	Jugland	Jugland	Jugland
Fag	Fag	Fag	Fag	Fag	Fag	Fag
Betul	Fag	Fag	Fag	Betul	Fag	Fag
Salic	Salic	Salic	Salic	Salic	Salic	Salic
Casuarin	Casuarin	Casuarin	Casuarin	Casuarin	Casuarin	Casuarin
Eucommi	Urtic	Urtic	Eucommi	Eucommi	Eucommi	Hamamelid Eucommiineae

TABLE 1.—continued.

Family	Goldberg	Cronquist 1981	Takhtajan 1983	Thorne 1983	Dahlgren 1983	Emberger 1960
Barbey	Urtic	Urtic	Barbey	—	Urtic	in Ulmaceae
Urtic	Urtic	Urtic	Urtic	Urtic	Urtic	Urtic
Cannab	Urtic	Urtic	Urtic	Urtic	Urtic	in Moraceae
Mor	Urtic	Urtic	Urtic	in Urticaceae	Urtic	Urtic
Ulm	Urtic	Urtic	Urtic	Urtic	Urtic	Urtic
Caesalpini	Fab	Fab	in Fabaceae	in Fabaceae	Fab	Ros
Fab	Fab	Fab	Fab	Rut	Fab	Ros
				Fabineae		
Mimos	Fab	Fab	in Fabaceae	in Fabaceae	Fab	Ros
Papaver	Papaver	Papaver	Papaver	Berberid	Papaver	Rhoead
				Papaverineae		
Fumari	Papaver	Papaver	in Papaveraceae	in Papaveraceae	Papaver	in Papaveraceae
Tovari	Papaver	Cappar	Cappar	in Capparaceae	Cappar	Rhoead
			Capparineae			
Cappar	Papaver	Cappar	Cappar	Cappar	Cappar	Rhoead
			Capparineae			
Pentadiplandr	Papaver	in Capparaceae	in Capparaceae	in Capparaceae	in Capparaceae	Olac
Resed	Papaver	Cappar	Cappar	Cappar	Cappar	Rhoead
			Resedineae			
Brassic	Papaver	Cappar	Cappar	Cappar	Cappar	Rhoead
			Capparineae			
Moring	Papaver	Cappar	Cappar	Cappar	Cappar	Rhoead
			Moringineae			
Bretschneider	Papaver	Sapind	Sapind	Rut	Sapind?	Rhoead
				Sapindineae		
Bat	Bat	Bat	Sapind	Rut	Cappar	Batid
				Sapindineae		
Dilleni	Dilleni	Dilleni	Dilleni	The	Dilleni	Pariet
				Dilleniineae		
Actinidi	Dilleni	The	Eric	The	Eric	Pariet
				Theineae		
Saurau	Dilleni	in Actinidiaceae	in Actinidiaceae	in Actinidiaceae	in Actinidiaceae	Pariet
The	The	The	The	The	The	Pariet
				Theineae		
Pentaphylac	The	The	The	The	The?	Terebinth
				Clethrineae		
Bonneti	The	in Theaceae	The	in Clusiaceae	in Theaceae	in Theaceae
Pellicier	The	The	The	in Theaceae	in Theaceae	in Theaceae
Medusagyn	The	The	The	The	The?	Pariet
				Scytopenalineae		
Eucryphi	The	Ros	Saxifrag	Ros	Cunoni	Pariet
			Cunoniineae	Cunoniineae		
Paracryphi	The	The	Celastr	The	Corn	in Eucryphiaceae
			Icacineae	Theineae		
Symploc	The	Eben	Eben	The	Corn	Eben
			Styracineae	Theineae		
Tetramerist	The	The	The	in Theaceae	in Theaceae	in Theaceae
Clusi	The	The	The	The	The	Pariet
				Hypericineae		
Quiin	The	The	The	The	The	Pariet
				Scytopenalineae		
Hyperic	The	in Clusiaceae	in Clusiaceae	in Clusiaceae	in Clusiaceae	in Guttiferae
Elatin	The	The	The	The	The	Pariet
				Hypericineae		
Dipterocarp	The	The	Malv	Malv	Malv	Pariet
Humiri	The	Lin	Gerani	Gerani	Gerani	Gerani
			Linineae	Linineae		
Ancistroclad	The	Viol	The	The	The	Pariet
				Scytopenalineae		

TABLE 1.—continued.

Family	Hutchinson 1973	Melchior 1964	Stebbins 1974	Rouleau 1981	Young 1981	Benson 1979
Barbey	Urtic	in Ulmaceae	Urtic	Barbey	Ole	—
Urtic	Urtic	Urtic	Urtic	Urtic	Urtic	Urtic
Cannab	Urtic	in Moraceae	Urtic	Urtic	Urtic	Urtic
Mor	Urtic	Urtic	Urtic	Urtic	Urtic	Urtic
Ulm	Urtic	Urtic	Urtic	Urtic	Urtic	Urtic
Caesalpini	Legumin	in Leguminosae	in Leguminosae	Fab	Fab	in Leguminosae
Fab	Legumin	Ros	Fab	Fab	Fab	Fab
		Leguminosineae				
Mimos	Legumin	in Leguminosae	in Leguminosae	Fab	Fab	in Leguminosae
Papaver	Rhead	Papaver	Papaver	Papaver	Ranuncul	Papaver
		Papaverineae				Papaverineae
Fumari	Rhead	in Papaveraceae	Papaver	Papaver	Ranuncul	Papaver
						Papaverineae
Tovari	Cappar	Papaver	Capper	Capper	Capper	Papaver
		Capparineae				Capparidineae
Cappar	Cappar	Papaver	Cappar	Cappar	Cappar	Papaver
		Capparineae				Capparidineae
Pentadiplandr	Celastr	in Capparaceae	—	Cappar	—	—
Resed	Resed	Papaver	Cappar	Cappar	Cappar	Papaver
		Resedineae				Capparidineae
Brassic	Brassic	Papaver	Cappar	Cappar	Cappar	Papaver
		Capparineae				Capparidineae
Moring	Cappar	Papaver	Cappar	Cappar	Cappar	Papaver
		Moringineae				Capparidineae
Bretschneider	in Sapindaceae	Sapind	—	Sapind	Sapind	Sapind
		Sapindineae				Sapindineae
Bat	Chenopodi	Bat	Bat	Caryophyll	Cappar	Batid
Dilleni	Dilleni	Guttifer	Dilleni	Dilleni	Dilleni	Dilleni
		Dilleniineae				
Actinidi	The	Guttifer	Eric?	Eric	The	The
		Dilleniineae				
Saurau	The	in Actinidiac	—	Eric	—	—
The	The	Guttifer	The	The	The	The
		Theineae				
Pentaphylac	The	Celastr	—	The	The	The
		Celastrineae				
Bonneti	The	in Theaceae	—	The	—	—
Pellicier	The	in Theaceae	—	The	—	—
Medusagyn	The	Guttifer	The	The	Scytometal	The
		Dilleniineae				
Eucryphi	Guttifer	Guttifer	Ros	Saxifrag	Cunoni	Ros
		Dilleniineae				
Paracryphi	—	—	—	Saxifrag	The	—
Symploc	Styrac	Eben	Eben	Eben	Eben	Eben
		Ebenineae				
Tetramerist	The	in Theaceae	—	The	—	—
Clusi	Guttifer	Guttifer	The	The	—	The
		Theineae				
Quiin	Guttifer	Guttifer	The	The	Scytometal	The
		Theineae				
Hyperic	Guttifer	in Guttiferae	in Guttiferae?	The	Hyperic	in Guttiferae
Elatin	Caryophyll	Viol	The	The	Hyperic	The
		Tamaricineae				
Dipterocarp	Ochn	Guttifer	The	The	Malv	The
		Ochnineae				
Humiri	Malpighi	in Linaceae	Gerani	Gerani	Lin	—
Ancistroclad	Ochn	Guttifer	Viol?	The	Lin	?
		Ancistrocladin				

TABLE 1.—continued.

Family	Goldberg	Cronquist 1981	Takhtajan 1983	Thorne 1983	Dahlgren 1983	Emberger 1960
Marcgravi	The	The	The	The Theineae	The	Pariet
Caryocar	The	The	The	The Theineae	The	Pariet
Ochn	The	The	The	The Scytopetalineae	The	Pariet
Strasburgeri	The	in Ochnaceae	The	The Scytopetalineae	The	Pariet
Diegodendr	The	in Ochnaceae	The	in Sphaerosepalac	—	—
Sphaerosepal	The	The	Malv	The Scytopetalineae	Malv?	Pariet
Scytopetal	The	The	Malv	The Scytopetalineae	The?	Malv
Sarcolaen	The	The	Malv	Malv	Malv	Malv
Eben	Eben	Eben	Eben Ebenineae	Eben Ebenineae	Eben	Eben
Sapot	Eben	Eben	Eben Ebenineae	Eben Ebenineae	Eben	Eben
Styrac	Styrac	Eben	Eben Styracineae	Eben Styracineae	Eben	Eben
Lissocarp	Styrac	Eben	Eben Styracineae	Eben Ebenineae	Eben	Eben?
Alangi	Styrac	Corn	Corn	Corn Cornineae	Corn	Umbell
Flacourti	Viol	Viol	Viol Violineae	Viol Violineae	Viol	Pariet
Lacistemat	Viol	Viol	in Flacourtiac	in Flacourtiaceae	in Flacourtiaceae	Pariet
Passiflor	Viol	Viol	Viol Violineae	Viol Violineae	Viol	Pariet
Malesherbi	Viol	Viol	Viol Violineae	Viol Violineae	Viol	Pariet
Turner	Viol	Viol	Viol Violineae	Viol Violineae	Viol	Pariet
Achari	Viol	Viol	Viol Violineae	Viol Violineae	Viol	Pariet
Caric	Viol	Viol	Viol Violineae	Viol Violineae	Viol	Pariet
Viol	Viol	Viol	Viol Violineae	Viol Violineae	Viol	Pariet
Stachyur	Viol	Viol	Viol Violineae	The Theineae	The	Pariet
Scyphostegi	Viol	Viol	Viol Violineae	Viol Violineae	Viol	Urtic?
Peridisc	Viol	Viol	Viol Violineae	Viol Violineae	Viol?	—
Hoplestigmat	Viol	Viol	Polemoni Boraginineae	—	Boragin?	Tubiflor
Loas	Viol	Viol	Loas	Loas	Loas	Pariet
Cucurbit	Viol	Viol	Viol Cucurbitineae	Viol Cucurbitineae	Cucurbit	Cucurbit
Cist	Cist	Viol	Viol Violineae	Malv	Malv	Pariet
Cochlosperm	Cist	in Bixaceae	in Bixaceae?	Malv	Malv	Pariet
Bix	Cist	Viol	Viol Violineae	Malv	Malv	Pariet
Eric	Eric	Eric	Eric	Eric	Eric	Eric
Clethr	Eric	Eric	Eric	The Clethrineae	Eric	Eric

Table 1.—continued.

Family	Hutchinson 1973	Melchior 1964	Stebbins 1974	Rouleau 1981	Young 1981	Benson 1979
Marcgravi	The	Guttifer Theineae	The	The	The	The
Caryocar	The	Guttifer Theineae	The	The	The	The
Ochn	Ochn	Guttifer Ochnineae	The	The	Scytopetal	The
Strasburgeri	Ochn	Guttifer Ochnineae	—	The	Scytopetal	The
Diegodendr	Ochn	—	—	The	—	—
Sphaerosepal	Ochn	Viol Cistineae	Malv?	Malv	Scytopetal	?
Scytopetal	Tili	Malv Scytopetalin	Malv	Malv	Scytopetal	Malv
Sarcolaen	Ochn	Malv Sarcolaenineae	Malv?	Malv	Malv	Malv
Eben	Eben	Eben Ebenineae	Eben	Eben	Eben	Eben
Sapot	Eben	Eben Sapotineae	Eben	Eben	Eben	Eben
Styrac	Styrac	Eben Ebenineae	Eben	Eben	Eben	Eben
Lissocarp	Styrac	Eben Ebenineae	Eben	Eben	Eben	Eben
Alangi	Arali	Umbell	Corn	Corn	Corn	Corn
Flacourti	Bix	Viol Flacourtiineae	Viol	Viol	Viol	Viol
Lacistemat	Bix	in Flacourtiac	—	Viol	in Flacourtiac	—
Passiflor	Passiflor	Viol Flacourtiineae	Viol	Passiflor	Viol	Viol
Malesherbi	Passiflor	Viol Flacourtiineae	Viol	Passiflor	Viol	Viol
Turner	Loas	Viol Flacourtiineae	Viol	Passiflor	Viol	Viol
Achari	Passiflor	Viol Flacourtiineae	Viol	Passiflor	Viol	Viol
Caric	Cucurbit	Viol Caricineae	Viol	Passiflor	Viol	Viol
Viol	Viol	Viol Flacourtiineae	Viol	Viol	Viol	Viol
Stachyur	Hamamelid	Viol Flacourtiineae	The	Viol	The	The
Scyphostegi	Celastr	Viol Flacourtiineae	Viol	Viol	Viol	Viol
Peridisc	Bix	Viol Flacourtiineae	Viol	Viol	Viol	Viol
Hoplestigmat	Bix	Eben Ebenineae	Polemoni?	Boragin	Boragin	?
Loas	Loas	Viol Loasineae	Viol?	Loas	Loas	Loas
Cucurbit	Cucurbit	Cucurbit	Viol	Cucurbit	Viol	Loas
Cist	Bix	Viol Cistineae	Viol	Viol	Malv	Viol
Cochlosperm	Bix	Viol Cistineae	—	Viol	Malv	Viol
Bix	Bix	Viol Cistineae	Viol	Viol	Malv	Viol
Eric	Eric	Eric	Eric	Eric	Eric	Eric
Clethr	Eric	Eric	Eric	Eric	The	Ericineae in Ericaceae

TABLE 1.—continued.

Family	Goldberg	Cronquist 1981	Takhtajan 1983	Thorne 1983	Dahlgren 1983	Emberger 1960
Pyrol	Eric	Eric	in Ericaceae	in Ericaceae	Eric	Eric
Monotrop	Eric	Eric	in Ericaceae	in Ericaceae	Eric	in Pyrolaceae
Empetr	Eric	Eric	Eric	Eric	Eric	Eric
Epacrid	Eric	Eric	Eric	Eric	Eric	Eric
Diapensi	Eric	Diapensi	Eric	Ros	Eric	Eric?
Cyrill	Eric	Eric	Eric	Saxifragineae	Eric	Terebinth
Lenno	Eric?	Lami	Polemoni	The	Boragin?	Tubiflor
			Clethrineae			
			Solan			
			Boraginineae			
Hydnor	Rafflesi	Rafflesi	Rafflesi	Rafflesi	Rafflesi	Aristolochi
Rafflesi	Rafflesi	Rafflesi	Rafflesi	Rafflesi	Rafflesi	Aristolochi
Balanophor	Balanophor	Santal	Balanophor	Balanophor	Balanophor	Santal
Ctenolophon	Celastr	in Hugoniaceae	in Linaceae	Gerani	Gerani	in Linaceae
				Linineae		
Ixonanth	Celastr	Lin	in Linaceae	in Linaceae	Gerani	in Linaceae
Irvingi	Celastr	in Simaroubaceae	in Simaroubaceae	in Rutaceae	in Simaroubaceae	in Simaroubaceae
Dichapetal	Celastr	Celastr	Euphorbi	Euphorbi	Euphorbi	Euphorbi
Celastr	Celastr	Celastr	Celastr	Celastr	Celastr	Celastr
			Celastrineae			
Goupi	Celastr	in Celastraceae	Celastr	in Celastraceae	in Celastraceae	in Celastraceae
			Celastrineae			
Siphonodont	Celastr	in Celastraceae	Celastr	in Celastraceae	in Celastraceae	—
			Celastrineae			
Vit	Rhamn	Rhamn	Rhamn	Corn	Vit	Rhamn
				Vitineae		
Lee	Rhamn	Rhamn	Rhamn	in Vitaceae	in Vitaceae	Rhamn
Rhamn	Rhamn	Rhamn	Rhamn	Rhamn	Rhamn	Rhamn
Erythropal	Rhamn	in Olacaceae	in Olacaceae?	in Olacaceae	—	Celastr
Aquifoli	Rhamn	Celastr	Celastr	The	Corn	Celastr
			Icacinineae			
Icacin	Rhamn	Celastr	Celastr	The	Corn	Celastr
			Icacinineae			
Cact	Caryophyll	Caryophyll	Caryophyll	Theineae		
			Phytolaccineae			
Aizo	Caryophyll	Caryophyll	Caryophyll	Chenopodi	Caryophyll	Centrosperm
			Phytolaccineae			
Portulac	Caryophyll	Caryophyll	Caryophyll	Portulacineae	Caryophyll	Centrosperm
			Phytolaccineae			
Theligon	Caryophyll	Rubi	Gentian	Chenopodi	Caryophyll	Centrosperm
				Portulacineae		
Didiere	Caryophyll	Caryophyll	Caryophyll	in Rubiaceae	Gentian	Centrosperm?
			Phytolaccineae			
Gyrostemon	Caryophyll	Bat	Sapind	Chenopodi	Caryophyll	Terebinth?
				Portulacineae		
Phytolacc	Caryophyll	Caryophyll	Caryophyll	Rut	Cappar	Centrosperm
			Phytolaccineae			
Barbeui	Caryophyll	in Phytolaccac	in Phytolaccaceae	Sapindineae		
				Chenopodi	Caryophyll	Centrosperm
Achatocarp	Caryophyll	Caryophyll	Caryophyll	Chenopodi		
			Phytolaccineae			
Petiveri	Caryophyll	in Phytolaccac	in Phytolaccaceae	Chenopodi	in Phytolaccaceae	in Phytolaccaceae
Agdestid	Caryophyll	in Phytolaccac	in Phytolaccaceae	Chenopodi	in Phytolaccaceae	in Phytolaccaceae
Nyctagin	Caryophyll	Caryophyll	Caryophyll	Chenopodi	Caryophyll	Centrosperm
			Phytolaccineae			
Stegnospermat	Caryophyll	in Phytolaccac	Caryophyll	Chenopodi	Caryophyll	—
			Phytolaccineae			
Caryophyll	Caryophyll	Caryophyll	Caryophyll	Chenopodi	Caryophyll	Centrosperm
			Caryophyllineae			
				Chenopodiineae		

TABLE 1.—continued.

Family	Hutchinson 1973	Melchior 1964	Stebbins 1974	Rouleau 1981	Young 1981	Benson 1979
Pyrol	Eric	Eric	Eric	Eric	—	in Ericaceae
Monotrop	Eric	in Pyrolaceae	Eric	Eric	—	in Ericaceae
Empetr	Celastr	Eric	Eric	Eric	Eric	Eric Empetrineae
Epacrid	Eric	Eric	Eric	Eric	Eric	Eric Ericineae
Diapensi	Eric	Diapensi	Diapensi	Diapensi	Diapensi	Eric Diapensiineae
Cyrtill	Celastr	Celastr	Eric	Eric	The	Eric Ericineae
Lenno	Eric	Tubiflorae Boraginineae	Polemoni	Boragin	Boragin	Polemoni Polemoniin
Hydnor	Aristolochi	Aristolochi	Rafflesi	Rafflesi	Rafflesi	Rafflesi
Rafflesi	Aristolochi	Aristolochi	Rafflesi	Rafflesi	Rafflesi	Rafflesi
Balanophor	Santal	Balanophor	Santal	Balanophor	Balanophor	Santal
Ctenolophon	Malpighi	in Linaceae	—	Gerani	—	—
Ixonanth	Malpighi	in Linaceae	—	Gerani	—	—
Irvingi	Malpighi	in Simaroubac	—	—	—	—
Dichapetal	Ros	Thymelae	Celastr?	Euphorbi	Euphorbi	?
Celastr	Celastr	Celastr	Celastr	Celastr	Celastr	Sapind Celastrineae
Goupi	Celastr	in Celastraceae	—	Celastr	—	—
Siphonodont	Celastr	in Celastraceae	Celastr	Celastr	—	—
Vit	Rhamn	Rhamn	Rhamn	Rhamn	Vit	Rhamn
Lee	in Vitaceae	Rhamn	Rhamn	Rhamn	—	—
Rhamn	Rhamn	Rhamn	Rhamn	Rhamn	Rhamn	Rhamn
Erythrolal	Celastr	in Olacaceae	—	Santal	—	—
Aquifoli	Celastr	Celastr	Celastr	Celastr	The	Sapind Celastrineae
Icacin	Celastr	Celastr	Celastr	Celastr	The	Sapind Celastrineae
Cact	Cact	Cact	Caryophyll	Caryophyll	Caryophyll	Cact
Aizo	Caryophyll	Centrospermae	Caryophyll	Caryophyll	Caryophyll	Caryophyll
Portulac	Caryophyll	Centrospermae	Caryophyll	Caryophyll	Caryophyll	Caryophyll
Theligon	Chenopodi	Myrt	Halorag?	Theligon	in Rubiaceae	?
Didiere	Sapind	Myrtineae	Caryophyll	Caryophyll	Chenopodi	Caryophyll
Gyrostemon	Chenopodi	Centrospermae?	—	Caryophyll	Cappar	Caryophyll
Phytolacc	Chenopodi	Centrospermae	Caryophyll	Caryophyll	Chenopodi	Caryophyll
Barbeui	Chenopodi	in Phytolacc	—	Caryophyll	Chenopodi	—
Achatocarp	Bix	Centrospermae	—	Caryophyll	Chenopodi	—
Petiveri	Chenopodi	in Phytolacc	—	—	Chenopodi	in Phytolaccaceae
Agdestid	Chenopodi	in Phytolacc	—	Caryophyll	Chenopodi	in Phytolaccaceae
Nyctagin	Thymelae	Centrospermae	Caryophyll	Caryophyll	Chenopodi	Caryophyll
Stegnospermat	Pittospor	in Phytolacc	—	Caryophyll	Chenopodi	—
Caryophyll	Caryophyll	Centrospermae	Caryophyll	Caryophyll	Caryophyll	Caryophyll

TABLE 1.—continued.

Family	Goldberg	Cronquist 1981	Takhtajan 1983	Thorne 1983	Dahlgren 1983	Emberger 1960
Mollugin	Caryophyll	Caryophyll	Caryophyll	in Aizoaceae	Caryophyll	in Aizoaceae
Illecebr	Caryophyll	in Caryophyllac	Caryophyllineae	in Caryophyllac	in Caryophyllac	—
Basell	Caryophyll	Caryophyll	in Caryophyllaceae	Chenopodi	Caryophyll	Centrosperm
			Phytolaccineae	Portulacineae		
Amaranth	Caryophyll	Caryophyll	Caryophyll	Chenopodi	Caryophyll	Centrosperm
			Chenopodiineae	Chenopodiineae		
Chenopodi	Caryophyll	Caryophyll	Caryophyll	Chenopodi	Caryophyll	Centrosperm
			Chenopodiineae	Chenopodiineae		
Primul	Primul	Primul	Primul	Primul	Primul	Primul
				Primulineae		
Plumbagin	Primul	Plumbagin	Plumbagin	Primul	Plumbagin	Plumbagin
				Plumbaginineae		
Tamaric	Primul	Viol	Tamaric	Viol	Tamaric	Pariet
				Tamaricineae		
Frankeni	Primul	Viol	Tamaric	Viol	Tamaric	Pariet
				Tamaricineae		
Myrsin	Primul	Primul	Primul	Primul	Primul	Primul
				Primulineae		
Theophrast	Primul	Primul	Primul	in Primulaceae	Primul	Primul
Polygon	Polygon	Polygon	Polygon	Polygon	Polygon	Polygon
Plantagin	Plantagin	Plantagin	Scrophulari	Bignoni	Scrophulari	Tubiflor
			Scrophulariineae			
Euphorbi	Euphorbi	Euphorbi	Euphorbi	Euphorbi	Euphorbi	Euphorbi
Aextoxic	Euphorbi	Celastr	Euphorbi	Euphorbi	Euphorbi?	Terebinth
Pand	Euphorbi	Euphorbi	Euphorbi	Euphorbi	Euphorbi	Pand
Sterculi	Malv	Malv	Malv	Malv	Malv	Malv
Elaeocarp	Malv	Malv	Malv	Malv	Malv	Malv
Tili	Malv	Malv	Malv	Malv	Malv	Malv
Malv	Malv	Malv	Malv	Malv	Malv	Malv
Bombac	Malv	Malv	Malv	Malv	Malv	Malv
Ros	Ros	Ros	Ros	Ros	Ros	Ros
				Rosineae		
Corynocarp	Ros	Celastr	Celastr	Ros	Celastr?	Terebinth?
			Celastrineae	Cunoniineae		
Crossosomat	Ros	Ros	Dilleni	Ros	Ros	Ros
				Rosineae		
Neurad	Ros	Ros	Ros	in Rosaceae	Ros	in Rosaceae
Coriari	Ros?	Ranuncul	Rut	Rut	Sapind	Terebinth
			Coriariineae	Coriariineae		
Myrt	Myrt	Myrt	Myrt	Myrt	Myrt	Myrt
			Myrtineae	Myrtineae		
Lecythid	Myrt	Lecythid	Myrt	The	The	Myrt
			Lecythidineae	Lecythidineae		
Barringtoni	Myrt	in Lecythidaceae	in Lecythidaceae	—	in Lecythidaceae	in Myrtaceae
Asteranth	Myrt	in Lecythidaceae	in Lecythidaceae	in Lecythidaceae	in Lecythidaceae	in Myrtaceae
Dialypetalanth	Myrt	Ros	Gentian	Gentian	Gentian	Myrt
Sonnerati	Myrt	Myrt	Myrt	in Lythraceae	in Lythraceae	Myrt
			Myrtineae			
Punic	Myrt	Myrt	Myrt	in Lythraceae	in Lythraceae	Myrt
			Myrtineae			
Rhizophor	Myrt	Rhizophor	Myrt	Corn	Rhizophor	Myrt
			Rhizophorineae	Rhizophorineae		

TABLE 1.—continued.

Family	Hutchinson 1973	Melchior 1964	Stebbins 1974	Rouleau 1981	Young 1981	Benson 1979
Mollugin	Caryophyll	Centrospermae	Caryophyll	Caryophyll	Caryophyll	in Aizoaceae
Illecebr Basell	Polygon Chenopodi	in Caryophyllac Centrospermae	— Caryophyll	Caryophyll Caryophyll	— Chenopodi	in Caryophyllaceae Caryophyll
Amaranth	Chenopodi	Centrospermae	Caryophyll	Caryophyll	Chenopodi	Caryophyll
Chenopodi	Chenopodi	Centrospermae	Caryophyll	Caryophyll	Chenopodi	Caryophyll
Primul	Primul	Primul	Primul	Primul	Primul	Primul
Plumbagin	Primul	Plumbagin	Plumbagin	Plumbagin	Plumbagin	Primul
Tamaric	Tamaric	Viol Tamaricineae	Viol	Tamaric	Tamaric	Tamaric
Frankeni	Tamaric	Viol Tamaricineae	Viol	Tamaric	Tamaric	Tamaric
Myrsin	Myrsin	Primul	Primul	Primul	Primul	Primul
Theophrast Polygon Plantagin	Myrsin Polygon Plantagin	Primul Polygon Plantagin	Primul Polygon Plantagin	Primul Polygon Scrophulari	Primul Plumbagin Bignoni	Primul Caryophyll Plantagin
Euphorbi	Euphorbi	Gerani Euphorbiineae	Euphorbi	Euphorbi	Euphorbi	Euphorbi
Aextoxic	Celastr	Sapind Sapindineae	Euphorbi	Celastr	Euphorbi	Euphorbi
Pand	Celastr	Celastr Celastrineae	Euphorbi	Euphorbi	Euphorbi	Euphorbi
Sterculi	Tili	Malv Malvineae	Malv	Malv	Malv	Malv
Elaeocarp	in Tiliaceae	Malv Elaeocarpaceae	Malv	Malv	Malv	Malv
Tili	Tili	Malv Malvineae	Malv	Malv	Malv	Malv
Malv	Malv	Malv Malvineae	Malv	Malv	Malv	Malv
Bombac	Tili	Malv Malvineae	Malv	Malv	Malv	Malv
Ros	Ros	Ros Rosineae	Ros	Ros	Ros	Ros
Corynocarp	Celastr	Celastr Celastrineae	Celastr?	Celastr	Celastr	?
Crossosomat	Dilleni	Guttifer Dilleniineae	Dilleni	Dilleni	Ros	Ros
Neurad	in Rosaceae	Ros Rosineae	Ros	Ros	—	in Rosaceae
Coriari	Coriari	Sapind Coriariineae	Sapind?	Rut	Rut	?
Myrt	Myrt	Myrt Myrtineae	Myrt	Myrt	Myrt	Myrt
Lecythid	Myrt	Myrt Myrtineae	Lecythid	Myrt	Lecythid	Myrt
Barringtoni Asteranth	Myrt Myrt as Napoleonaeaceae	in Lecythidac in Lecythidac	— —	Myrt Myrt	— —	— —
Dialypetalanth	Rubi	Myrt Myrtineae	Myrt	Gentian	—	—
Sonnerati	Myrt	Myrt Myrtineae	Myrt	Myrt	Myrt	Myrt
Punic	Myrt	Myrt Myrtineae	Myrt	Myrt	—	Myrt
Rhizophor	Myrt	Myrt Myrtineae	Myrt	Myrt	Rhizophor	Myrt

TABLE 1.—continued.

Family	Goldberg	Cronquist 1981	Takhtajan 1983	Thorne 1983	Dahlgren 1983	Emberger 1960
Lythr	Myrt	Myrt	Myrt	Myrt	Myrt	Myrt
Crypteroni	Myrt	Myrt	Myrtineae	Myrtineae	Myrt	Myrt
Olini	Myrt	Myrt	Myrtineae	Lythrineae	Myrt	Thymelae
Melastomat	Myrt	Myrt	Myrtineae	Lythrineae	Myrt	Myrt
Onagr	Myrt	Myrt	Myrtineae	Lythrineae	Myrt	Myrt
Trap	Myrt	Myrt	Myrtineae	Onagrineae	Myrt	Myrt
Combret	Myrt	Myrt	Myrtineae	Lythrineae	Myrt	Myrt
Penae	Myrt	Myrt	Myrtineae	Lythrineae	Myrt	Thymelae
Saxifrag	Saxifrag	Ros	Saxifrag	Ros	Saxifrag	Ros
Crassul	Saxifrag	Ros	Saxifragineae	Saxifragineae	Saxifrag	Ros
Parnassi	Saxifrag	in Saxifragaceae	Saxiphrag	Ros	Droser	in Saxifragaceae
Eremosyn	Saxifrag	in Saxifragaceae	Saxifragineae	in Saxifragaceae	Corn?	—
Franco	Saxifrag	in Saxifragaceae	Saxifragineae	in Saxifragaceae	in Saxifragaceae	in Saxifragaceae
Davidsoni	Saxifrag	Ros	Saxifrag	Ros	Cunoni	in Cunoniaceae
Hydrange	Saxifrag	Ros	Cunoniineae	Cunoniineae	Corn	in Saxifragaceae
Philadelph	Saxifrag	in Hydrangeaceae	Pittosporineae	in Saxifragaceae	—	in Saxifragaceae
Pterostemon	Saxifrag	in Grossulari	Saxifrag	in Saxifragaceae	Corn?	in Saxifragaceae
Ite	Saxifrag	in Grossulari	Pittosporineae	in Saxifragaceae	Saxifrag	in Saxifragaceae
Bauer	Saxifrag	in Cunoniaceae	in Escalloniaceae	Ros	Cunoni	in Saxifragaceae
Bruni	Saxifrag	Ros	Cunoniineae	Cunoniineae	Cunoni	Ros
Vahli	Saxifrag	in Saxifragaceae	Saxifrag	Pittospor	in Saxifragaceae	—
Donati	Saxifrag	Campanul	Pittosporineae	Bruniineae	in Saxifragaceae	in Styliidiaceae
Tetracarpae	Saxifrag	in Grossulari	Saxifragineae	in Saxifragaceae	in Styliidiaceae	in Styliidiaceae
Escalloni	Saxifrag	in Grossulari	Campanulineae	in Saxifragaceae	Corn?	in Saxifragaceae
Grossulari	Saxifrag	Ros	in Escalloniaceae	in Saxifragaceae	Corn	in Saxifragaceae
Brunelli	Saxifrag	Ros	Saxifrag	in Saxifragaceae	Saxifrag	in Saxifragaceae
Cunoni	Saxifrag	Ros	Saxifragineae	Ros	Cunoni	Ros
Greyi	Saxifrag	Ros	Cunoniineae	Cunoniineae	Cunoni	Ros
Cephalot	Saxifrag	Ros	Saxifrag	Ros	Saxifrag	Ros
Dioncophyll	Droser	Viol	Saxifragineae	Saxifragineae	Saxifrag	Sarraceni
Droser	Droser	Nepenth	Saxifrag	Ros	The	Pariet
Byblid	Droser	Ros	The	Scytometalineae	Droser	Pariet
Podostem	Droser	Podostem	Saxifragineae	Ros	Pittospor?	Ros
			Saxifragineae	Pittosporineae	Podostem	Ros
				Saxifragineae		

TABLE 1.—continued.

Family	Hutchinson 1973	Melchior 1964	Stebbins 1974	Rouleau 1981	Young 1981	Benson 1979
Lythr	Myrt	Myrt	Myrt	Myrt	Myrt	Myrt
Crypteroni	Cunoni	Myrtineae	Myrt	Saxifrag	—	Myrt
Olini	Cunoni	Myrtineae	Myrt	Myrt	Myrt	Myrt
Melastomat	Myrt	Myrtineae	Myrt	Myrt	Myrt	Myrt
Onagr	Onagr	Myrtineae	Myrt	Myrt	Myrt	Myrt
Trap	Onagr	Myrtineae	Myrt	Myrt	Myrt	Myrt
Combret	Myrt	Myrtineae	Myrt	Myrt	Myrt	Myrt
Penae	Thymelae	Thymelae	Myrt	Myrt	Myrt	Myrt
Saxifrag	Saxifrag	Ros	Ros	Saxifrag	Saxifrag	Ros
Crassul	Saxifrag	Saxifragineae	Ros	Saxifrag	Saxifrag	Ros
Parnassi	Saxifrag	Ros	—	Saxifrag	Saxifrag	in Saxifragaceae
Eremosyn	Saxifrag	Saxifragineae	—	Saxifrag	Hydrange	—
Franco	Saxifrag	in Saxifragac	—	Saxifrag	Saxifrag	in Saxifragaceae
Davidsoni	in Cunoniaceae	in Saxifragac	Ros	Saxifrag	Cunoni	—
Hydrange	Cunoni	Saxifragineae	Ros	Saxifrag	Hydrange	in Saxifragaceae
Philadelph	Cunoni	in Saxifragac	—	Saxifrag	Hydrange	in Saxifragaceae
Pterostemon	Cunoni	in Saxifragac	—	Saxifrag	Saxifrag	in Saxifragaceae
Ite	in Escalloniaceae	in Saxifragac	—	Saxifrag	Saxifrag	in Saxifragaceae
Bauer	Cunoni	in Saxifragac	—	Saxifrag	Saxifrag	in Saxifragaceae
Bruni	Hamamelid	Ros	Ros	Saxifrag	Bruni	Ros
Vahli	Saxifrag	Saxifragineae	—	Saxifrag	Saxifrag	—
Donati	Saxifrag	in Saxifragac	—	Saxifrag	Saxifrag	—
Tetracarpae	in Escalloniaceae	in Saxifragac	—	Saxifrag	Saxifrag	—
Escalloni	Cunoni	in Saxifragac	in Grossulariac	Saxifrag	Hydrange	in Saxifragaceae
Grossulari	Cunoni	in Saxifragac	Ros	Saxifrag	—	in Saxifragaceae
Brunelli	Dilleni	Ros	—	Saxifrag	Cunoni	Ros
Cunoni	Cunoni	Saxifragineae	Ros	Saxifrag	Cunoni	Ros
Greyi	Cunoni	Ros	Sapind	Sapind	Saxifrag	?
Cephalot	Saxifrag	in Melianthac	Ros	Saxifrag	Saxifrag	Ros
Dioncophyll	in Flacourtiaceae	Saxifragineae	Ros	Saxifrag	Saxifrag	Ros
Droser	Sarraceni	Guttifer	Viol?	The	Scytometal	?
Byblid	Pittospor	Ochnineae	Ros?	Nepenth	Saxifrag	Ros
Podostem	Podostem	Sarraceni	Ros	Saxifrag	Pittospor	Ros
		Ros	Podostem	Podostem	Podostem	Podostem
		Saxifragineae				
		Podostem				

TABLE 1.—continued.

Family	Goldberg	Cronquist 1981	Takhtajan 1983	Thorne 1983	Dahlgren 1983	Emberger 1960
Hydroptachy	Droser	Callitrich	Scrophulari Scrophulariineae	Pittospor Bruniineae	Hydrostachy	Ros
Begoni	Begoni	Viol	Begoni	Viol Begoniineae	Cucurbit	Pariet
Datisc	Begoni	Viol	Begoni	Viol Begoniineae	Cucurbit	Pariet
Arali	Api	Api	Arali	Arali	Arali	Umbell
Api	Api	Api	Arali	in Araliaceae	Arali	Umbell
Davidi	Corn	in Nyssaceae	Corn	in Nyssaceae	Corn	in Nyssaceae
Nyss	Corn	Corn	Corn	Corn Cornineae	Corn	Umbell
Garry	Corn	Corn	Corn	Corn Cornineae	Corn	Garry
Corn	Corn	Corn	Corn	Corn Cornineae	Corn	Umbell
Caprifoli	Dipsac	Dipsac	Dipsac	Dipsac	Corn	Rubi
Valerian	Dipsac	Dipsac	Dipsac	Dipsac	Dipsac	Rubi
Adox	Dipsac	Dipsac	Dipsac	Dipsac	Corn	Rubi
Dipsac	Dipsac	Dipsac	Dipsac	Dipsac	Dipsac	Rubi
Rut	Rut	Sapind	Rut Rutineae	Rut Rutineae	Rut	Terebinth
Cneor	Rut	Sapind	Rut Rutineae	Rut Rutineae	Rut	Cneor
Simaroub	Rut	Sapind	Rut Rutineae	Rut Rutineae	Rut	Terebinth
Burser	Rut	Sapind	Rut Rutineae	Rut Rutineae	Rut	Terebinth
Anacard	Rut	Sapind	Rut Rutineae	Rut Rutineae	Sapind	Terebinth
Meli	Rut	Sapind	Rut Rutineae	Rut Rutineae	Rut	Terebinth
Akani	Sapind	Sapind	Sapind	Rut Sapindineae	Sapind	Terebinth
Sapind	Sapind	Sapind	Sapind	Rut Sapindineae	Sapind	Terebinth
Melanth	Sapind	Sapind	Sapind	Rut Sapindineae	Sapind	Terebinth?
Hippocastan	Sapind	Sapind	Sapind	Rut Sapindineae	Sapind	Terebinth
Staphyle	Sapind	Sapind	Sapind	Ros Cunoniineae	Sapind	Celastr
Acer	Sapind	Sapind	Sapind	Rut Sapindineae	Sapind	Terebinth
Sabi	Sapind	Ranuncul	Sapind	Rut Sapindineae	Sapind	Terebinth?
Gerani	Gerani	Gerani	Gerani Geraniineae	Gerani Geraniineae	Gerani	Gerani
Viviani	Gerani	in Geraniaceae	in Geraniaceae	Gerani Geraniineae	Gerani	in Geraniaceae
Limnanth	Gerani	Gerani	Gerani Limnanthineae	Gerani Geraniineae	Tropaeol	Gerani
Oxalid	Gerani	Gerani	Gerani Geraniineae	Gerani Geraniineae	Gerani	Gerani
Connar	Gerani	Ros	Connar	Rut Fabineae	Sapind	Ros
Tropaeol	Gerani	Gerani	Gerani Balsaminineae	Gerani Geraniineae	Tropaeol	Gerani
Balsamin	Gerani	Gerani	Gerani Balsaminineae	Gerani Geraniineae	Balsamin	Terebinth?
Stackhousi	Gerani	Celastr	Celastr Celastrineae	Celastr	Celastr	Celastr

TABLE 1.—continued.

Family	Hutchinson 1973	Melchior 1964	Stebbins 1974	Rouleau 1981	Young 1981	Benson 1979
Hydrostachy	Podostem	Hydrostachy	Scrophulari	Scrophulari	Hydrostachy	?
Begoni	Cucurbit	Viol Begoniineae	Viol	Begoni	Viol	Loas
Datisc	Cucurbit	Viol Begoniineae	Viol	Begoni	Viol	Loas
Arali	Arali	Umbell	Umbell	Api	Arali	Umbell
Api	Umbell	Umbell	Umbell	Api	Arali	Umbell
Davidi	in Nyssaceae	Umbell	Corn	Corn	Corn	—
Nyss	Arali	Umbell	Corn	Corn	Corn	Corn
Garry	Arali	Umbell	Corn	Corn	Corn	Corn
Corn	Arali	Umbell	Corn	Corn	Corn	Corn
Caprifoli	Arali	Dipsac	Dipsac	Dipsac	Dipsac	Rubi
Valerian	Valerian	Dipsac	Dipsac	Dipsac	Dipsac	Rubi
Adox	Saxifrag	Dipsac	Dipsac	Dipsac	Dipsac	Rubi
Dipsac	Valerian	Dipsac	Dipsac	Dipsac	Dipsac	Rubi
Rut	Rut	Rut Rutineae	Sapind	Rut	Rut	Sapind Rutineae
Cneor	Celastr	Rut Rutineae	Sapind	Rut	Rut	Sapind Rutineae
Simaroub	Rut	Rut Rutineae	Sapind	Rut	Rut	Sapind Rutineae
Burser	Rut	Rut Rutineae	Sapind	Rut	Rut	Sapind Rutineae
Anacard	Sapind	Sapind Anacardiineae	Sapind	Rut	Rut	Sapind Rutineae
Meli	Meli	Rut Rutineae	Sapind	Rut	Rut	Sapind Rutineae
Akani	Sapind	Rut Rutineae	Sapind	Sapind	Sapind	Sapind Sapindineae
Sapind	Sapind	Sapind Sapindineae	Sapind	Sapind	Sapind	Sapind Sapindineae
Melianth	Sapind	Sapind Sapindineae	Sapind	Sapind	Sapind	Sapind Sapindineae
Hippocastan	Sapind	Sapind Sapindineae	Sapind	Sapind	Sapind	Sapind Sapindineae
Staphyle	Sapind	Celastr Celastrineae	Sapind	Sapind	Sapind	Sapind Sapindineae
Acer	Sapind	Sapind Sapindineae	Sapind	Sapind	Sapind	Sapind Sapindineae
Sabi	Sapind	Sapind Sapindineae	—	Sapind	Sapind	Sapind Sapindineae
Gerani	Gerani	Gerani Geraniineae	Gerani	Gerani	Gerani	Gerani
Viviani	Pittospor	in Geraniaceae	—	Gerani	—	—
Limnanth	Gerani	Gerani Limnanthineae	Gerani	Gerani	Tropaeol	Gerani
Oxalid	Gerani	Gerani Geraniineae	Gerani	Gerani	Gerani	Gerani
Connar	Dilleni	Ros Leguminosineae	Sapind	Connar	Fab	Ros
Tropaeol	Gerani	Gerani Geraniineae	Gerani	Gerani	Tropaeol	Gerani
Balsamin	Gerani	Sapind Balsamineae	Gerani	Gerani	Gerani	Gerani
Stackhousi	Celastr	Celastr Celastrineae	Celastr	Celastr	Celastr	Sapind Celastrineae

TABLE 1.—continued.

Family	Goldberg	Cronquist 1981	Takhtajan 1983	Thorne 1983	Dahlgren 1983	Emberger 1960
Lin	Gerani	Lin	Gerani Linineae	Gerani Linineae	Gerani	Gerani
Erythroxy	Gerani	Lin	Gerani Linineae	Gerani Linineae	Gerani	Gerani
Zygophyll	Gerani	Sapind	Rut Rutineae	Gerani Linineae	Gerani	Gerani
Balanit	Gerani	in Zygophyllac	Rut Rutineae	in Rutaceae	Gerani	in Zygophyllaceae
Malpighi	Gerani	Polygal	Polygal	Gerani Polygalineae	Polygal	Gerani
Polygal	Polygal	Polygal	Polygal	Gerani Polygalineae	Polygal	Terebinth
Krameri	Polygal	Polygal	Polygal	Gerani Polygalineae	Polygal?	in Caesalpiniaceae
Trigoni	Polygal	Polygal	Polygal	Gerani Polygalineae	Polygal	Terebinth
Vochysi	Polygal	Polygal	Polygal	Gerani Polygalineae	Polygal	Terebinth
Ole	Ole	Scrophulari	Ole	Ole	Ole	Ligustr
Salvador	Ole	Celastr	Celastr Celastrineae	Ole	Salvador	Celastr
Logani	Gentian	Gentian	Gentian	Gentian	Gentian	Rubi
Plocospermat	Gentian	in Apocynaceae	in Loganiaceae?	in Loganiaceae	—	in Loganiaceae?
Apocyn	Gentian	Gentian	Gentian	Gentian	Gentian	Contort
Asclepiad	Gentian	Gentian	Gentian	in Apocynaceae	Gentian	Contort
Convolvul	Gentian	Solan	Polemoni Convolvulineae	Solan Solanineae	Solan	Tubiflor
Cuscut	Gentian	Solan	Polemoni Convolvulineae	in Convolvulaceae	Solan	in Convolvulaceae
Rubi	Gentian	Rubi	Gentian	Gentian	Gentian	Rubi
Columelli	Gentian	Ros	Saxifrag Pittosporineae	in Saxifragaceae	Corn	Tubiflor?
Gentian	Gentian	Gentian	Gentian	Gentian	Gentian	Contort
Menyanth	Gentian	Solan	Gentian	Gentian	Gentian	Contort
Olac	Santal	Santal	Santal Santalineae	Santal	Santal	Olac
Aptandr	Santal	in Olacaceae	in Olacaceae	—	—	in Olacaceae
Octoknem	Santal	in Olacaceae	in Olacaceae	in Olacaceae	in Olacaceae	Santal
Opili	Santal	Santal	Santal Santalineae	in Olacaceae	Santal	Olac
Medusandr	Santal	Santal	Celastr Icacineae	Santal	—	Olac?
Cardiopterid	Santal	Celastr	Celastr Icacineae	The Theineae	Corn? or Celastr?	Celastr
Santal	Santal	Santal	Santal Santalineae	Santal	Santal	Santal
Loranth	Santal	Santal	Santal Loranthineae	Santal	Santal	Santal
Misodendr	Santal	Santal	Santal Santalineae	Santal	Santal	Santal
Grubbi	Santal	Eric	Eric	Pittospor Bruniineae	Cunoni	Santal
Geissolomat	Thymelae	Celastr	Celastr Celastrineae	Pittospor Bruniineae	Geissolomat	Thymelae
Gonystyl	Thymelae	in Thymelaeaceae	in Thymelaeaceae	in Thymelaeaceae	Thymelae or in Thymelaeaceae	Malv
Thymelae	Thymelae	Myrt	Thymelae	Euphorbi	Thymelae	Thymelae

TABLE 1.—continued.

Family	Hutchinson 1973	Melchior 1964	Stebbins 1974	Rouleau 1981	Young 1981	Benson 1979
Lin	Malpighi	Gerani Geraniineae	Gerani	Gerani	Lin	Gerani
Erythroxyl	Malpighi	Gerani Geraniineae	Gerani	Gerani	Lin	Gerani
Zygophyll	Malpighi	Gerani Geraniineae	Sapind?	Gerani	Lin	Gerani
Balanit	Malpighi	in Zygophyllac	—	Gerani	—	—
Malpighi	Malpighi	Rut Malpighiineae	Polygal?	Gerani	Polygal	Gerani
Polygal	Polygal	Rut Polygalineae	Polygal	Polygal	Polygal	Polygal
Krameri	Polygal	Ros Leguminosineae	Polygal	Polygal	Polygal	Polygal
Trigoni	Polygal	Rut Malpighiineae	Polygal	Polygal	Polygal	Polygal
Vochysi	Polygal	Rut Malpighiineae	Polygal	Polygal	Polygal	Polygal
Ole	Logani	Ole	Gentian?	Ole	Ole	Gentian Oleineae
Salvador	Celastr	Celastr Celastrineae	Celastr	Celastr	Ole	Sapind Celastrineae
Logani	Logani	Gentian	Gentian	Gentian	Gentian	Gentian Gentianineae
Plocospermat	Apocyn	—	—	Gentian	—	—
Apocyn	Apocyn	Gentian	Gentian	Gentian	Gentian	Gentian Apocinineae
Asclepiad	Apocyn	Gentian	in Apocynaceae	Gentian	Gentian	Gentian Apocynineae
Convolvul	Solan	Tubiflorae Convolvulineae	Polemoni?	Polemoni	Solan	Polemoni Polemoniineae
Cuscut	Polemoni	in Convolvulac	Polemoni?	Polemoni	in Convolvulac	in Convolvulaceae
Rubi	Rubi	Gentian	Rubi	Gentian	Gentian	Rubi
Columelli	Person	Tubiflorae Solanineae	Scrophulari?	Scrophulari	Hydrange	?
Gentian	Gentian	Gentian	Gentian	Gentian	Gentian	Gentian Gentianineae
Menyanth	Gentian	Gentian	Polemoni?	Gentian	Gentian	in Gentianaceae
Olac	Olac	Santal	Santal	Santal	Santal	Santal
Aptandr	Olac	in Olacaceae	—	Santal	—	—
Octoknem	Olac	in Olacaceae	—	Santal	—	—
Opili	Olac	Santal	Santal	Santal	—	Santal
Medusandr	Olac	Medusandr	Santal?	Santal	Celastr	?
Cardiopterid	Celastr	Celastr Icacineae	Celastr?	Santal	The	?
Santal	Santal	Santal	Santal	Santal	Santal	Santal
Loranth	Santal	Santal	Santal	Santal	Santal	Santal
Misodendr	Santal	Santal	Santal	Santal	Santal	Santal
Grubbi	Santal	Santal	Eric?	Eric	Pittospor	Santal
Geissolomat	Thymelae	Thymelae	Celastr	Celastr	Myrothamn	Myrt
Gonystyl	Thymelae	in Thymelaeac	—	—	—	—
Thymelae	Thymelae	Thymelae	Myrt	Thymelae	Euphorbi	Myrt

TABLE 1.—continued.

Family	Goldberg	Cronquist 1981	Takhtajan 1983	Thorne 1983	Dahlgren 1983	Emberger 1960
Polemoni	Polemoni	Solan	Polemoni	Solan	Solan	Tubiflor
Fouquieri	Polemoni	Viol	Polemoniineae	Polemoniineae	Fouquieri	Pariet
Hydrophyll	Polemoni	Solan	Tamaric	Fouquierineae		
Boragin	Polemoni	Solan	Polemoni	Solan	Boragin	Tubiflor
			Boraginineae	Boraginineae		
			Polemoni	Solan	Boragin	Tubiflor
			Boraginineae	Boraginineae		
Solan	Scrophulari	Solan	Scrophulari	Solan	Solan	Tubiflor
			Solanineae	Solanineae		
Nolan	Scrophulari	Solan	in Solanaceae	in Solanaceae	in Solanaceae	Tubiflor
Scrophulari	Scrophulari	Scrophulari	Scrophulari	Bignoni	Scrophulari	Tubiflor
			Scrophulariineae			
Buddlej	Scrophulari	Scrophulari	Scrophulari	Gentian	Scrophulari	Tubiflor
			Scrophulariineae			
Globulari	Scrophulari	Scrophulari	in Scrophulariac	in Scrophulariac	Scrophulari	Tubiflor
Lentibulari	Scrophulari	Scrophulari	Scrophulari	Bignoni	Scrophulari	Tubiflor
			Scrophulariineae			
Orobanch	Scrophulari	Scrophulari	Scrophulari	in Scrophulariac	in Scrophulariac	Tubiflor
			Scrophulariineae			
Acanth	Scrophulari	Scrophulari	Scrophulari	Bignoni	Scrophulari	Tubiflor
			Scrophulariineae			
Bignoni	Scrophulari	Scrophulari	Scrophulari	Bignoni	Scrophulari	Tubiflor
			Scrophulariineae			
Gesneri	Scrophulari	Scrophulari	Scrophulari	Bignoni	Scrophulari	Tubiflor
			Scrophulariineae			
Pedali	Scrophulari	Scrophulari	Scrophulari	Bignoni	Scrophulari	Tubiflor
			Scrophulariineae			
Myopor	Lami	Scrophulari	Scrophulari	Bignoni	Scrophulari	Tubiflor
			Scrophulariineae			
Verben	Lami	Lami	Lami	Lami	Lami	Tubiflor
Phrym	Lami	in Verbenaceae	in Verbenaceae	in Verbenaceae	in Verbenaceae	Tubiflor
Lami	Lami	Lami	Lami	Lami	Lami	Tubiflor
Campanul	Campanul	Campanul	Campanul	Campanul	Campanul	Synanther
			Campanulineae			
Goodeni	Campanul	Campanul	Campanul	Campanul	Goodeni	Synanther
			Goodeniineae			
Brunoni	Campanul	Campanul	in Goodeniaceae	in Goodeniaceae	in Goodeniaceae	Synanther
Calycer	Campanul	Calycer	Calycer	Dipsac	Dipsac	Rubi
Stylidi	Campanul	Campanul	Campanul	Ros	Corn	Synanther
			Campanulineae	Saxifragineae		
Aster	Aster	Aster	Aster	Aster	Aster	Synanther
Tremandr	?	Polygal	Polygal	Pittospor	Pittospor?	Terebinth?
				Pittosporineae		
Elaeagn	?	Prote	Elaeagn	Rhamn	Elaeagn	Thymelae
Pittospor	?	Ros	Saxifrag	Pittospor	Pittospor	Ros
			Pittosporineae	Pittosporineae		

one or more convergent characters or character states in common will differ from one another in most respects. I believe convergence is hardly ever prevalent enough to mask relationships.

If a family has more than one state of a character, the state considered primitive for the particular taxon rather than the derived one should be considered in attempting to determine the

TABLE 1.—continued.

Family	Hutchinson 1973	Melchior 1964	Stebbins 1974	Rouleau 1981	Young 1981	Benson 1979
Polemoni	Polemoni	Tubiflorae	Polemoni	Polemoni	Solan	Polemoni
Fouquieri	Tamaric	Convolvulineae	Viol	Tamaric	Solan	Polemoniineae
Hydrophyll	Polemoni	Tubiflorae	Polemoni	Boragin	Boragin	Fouquieri
Boragin	Boragin	Boraginineae	Polemoni?	Boragin	Boragin	Polemoni
Solan	Solan	Tubiflorae	Polemoni?	Scrophulari	Solan	Boraginineae
Nolan	Solan	Solanineae	Polemoni?	Scrophulari	—	Polemoni
Scrophulari	Person	Tubiflorae	Scrophulari	Scrophulari	Bignoni	Polemoniineae
Buddlej	Logani	Solanineae	Scrophulari	Scrophulari	Gentian	Scrophulari
Globulari	Lami	Tubiflorae	Scrophulari	Scrophulari	—	in Loganiaceae
Lentibulari	Person	Solanineae	Scrophulari	Scrophulari	Bignoni	Scrophulari
Orobanch	Person	Tubiflorae	Scrophulari	Scrophulari	in Scrophulariac	Scrophulari
Acanth	Person	Solanineae	Scrophulari	Scrophulari	Bignoni	Scrophulari
Bignoni	Bignoni	Tubiflorae	Scrophulari	Scrophulari	Bignoni	Scrophulari
Gesneri	Person	Solanineae	Scrophulari	Scrophulari	Bignoni	Scrophulari
Pedali	Bignoni	Tubiflorae	Scrophulari	Scrophulari	Bignoni	Scrophulari
Myopor	Lami	Solanineae	Scrophulari	Scrophulari	Bignoni	Scrophulari
Verben	Verben	Myoporineae	Lami	Lami	Lami	Lami
Phrym	Verben	Tubiflorae	Lami	Lami	—	Lami
Lami	Lami	Phrymineae	Lami	Lami	Lami	Lami
Campanul	Campan	Tubiflorae	Lami	Lami	Lami	Lami
Goodeni	Goodeni	Verbenineae	Campanul	Campanul	Campanul	Campanul
Brunoni	Goodeni	Campanul	Campanul	Goodeni	Campanul	Campanul
Calycer	Valerian	Campanul	Dipsac	Calycer	Dipsac	Campanul
Stylidi	Goodeni	Campanul	Campanul	Campanul	Hydrange	Campanul
Aster	Aster	Campanul	Aster	Aster	Aster	Aster
Tremandr	Pittospor	Rut	Polygal	Polygal	Polygal	?
Elaeagn	Rhamn	Polygalineae	Prote	Elaeagn	Rhamn	Elaeagn
Pittospor	Pittospor	Thymelae	Ros	Saxifrag	Pittospor	Ros
		Saxifragineae				

family's ancestor. A descendant has at least one more derived character or character state than its ancestor. Genera that are intermediate between families are particularly significant in a

phylogenetic study. They are the knots that tie the families together.

I have constructed a dendrogram suggesting relationships of the orders (page 27). Most of my

TABLE 2.—Evolutionary trends in dicotyledons (reversibility: n = not; r = rarely; c = commonly).

Character	Primitive state	Derived state	Reversibility
climate of origin	warm temperate	other	r
plant	mesophyte;	xerophyte;	r
	dioecious;	monoecious or bisexual;	r-c
	autotrophic	saprophytic or parasitic	n
indument	absent or sparse;	copious;	r
	simple	stellate or glandular	r
spines	absent	present	r
tendrils	absent	present	r
latex	absent	present	c
xylem vessel perforation	absent;	present;	n
plates	scalariform	simple	n
xylem vessel elements	long, narrow, angular in	short, wide, round in	n
and sieve tube elements	cross-section;	cross-section;	
	end plate slanting;	end plate transverse;	n
	pores small	pores large	n
intraxylary and inter-	absent	present	r
xylary phloem			
phloem companion cells	absent	present	n
leaves	alternate;	opposite or whorled;	r
	more than 2 ranks;	distichous;	r
	thin;	thick and sclerophyllous;	r
	large	small relative to size of	r
		plant	
leaf margin	entire	toothed	c
leaf venation	open	closed	n
leaf buds	small, naked	large, perulate	n
stipules	absent	present	r
stomates	anomocytic	other	n
leaves and flowers	formed and functional in	formed in 1 season and	n
	the same growing season	functional in the next	
inflorescence	racemose;	cymose;	n
	raceme;	corymb or spike;	n
	spike or umbel;	head;	n
	open cyme	fascicle	n
flowers	solitary;	in inflorescence;	c
	terminal;	axillary;	c
	unisexual;	bisexual;	c
	odorless;	scented;	c
	green, white, or yellow;	other colors;	c
	actinomorphic	zygomorphic	n
pollinated by	wind;	insects, birds, or mammals;	r
	various pollinators	particular pollinators	r
pollinators	Coleoptera;	Hymenoptera, Diptera,	r
		or Lepidoptera;	
	short-tongued	long-tongued	n
involucre	absent	present	n
receptacle	elongate or convex;	flat;	n
	flat	concave	n
perianth	absent;	monochlamydeous;	r

TABLE 2.—continued.

Character	Primitive state	Derived state	Reversibility
	monochlamydeous;	dichlamydeous;	r
	homiochlamydeous	heterochlamydeous	r
perianth spur	absent	present	r
perianth parts	imbricate	valvate	n
corona	absent	present	n
perianth vasculature	evident	absent or not evident	n
perianth parts, stamens and carpels	indefinite in number;	definite in number;	n
	spirally arranged;	whorled;	n
	separate	connate or adnate	n
stamens and carpels	pleiomerous;	isomerous;	n
	2 or more whorls;	1 whorl;	n
	isomerous	oligomerous	n
nectaries	absent	present	r
stamens	laminar, not differentiated into anther and filament;	differentiated into anther and filament;	n
	3 trace;	1 trace;	n
	longer than pistil;	equal to or shorter than pistil;	r
	equal in length;	anisostemonous;	r
staminodes	inserted on receptacle	inserted on perianth	n
anthers	absent	present	r
	separate;	connate;	r
	adnate or basifixed;	dorsifixed;	r
	oblong;	about as long as wide;	r
	dehiscent by slits;	poricidal or valvate;	n
	extrorse or latrorse	introrse	r
connective	abundant	sparse or absent	n
microsporangia	4 per anther;	2 or 1 per anther;	n
	dorsal or dorsal and ventral	ventral	n
pollen grains	monosulcate;	colpi 3 or more;	n
	smooth;	sculptured;	r
	not sticky;	sticky;	r
	free	united in tetrads, small masses, or pollinia	n
cells in pollen grains at time of dispersal	2	3	n
carpels	open	closed	n
ovary	number of locules correspond to number of carpels;	unilocular in 2-∞ carpellate pistil;	r
	superior	semi-inferior to inferior	n
style(s)	absent;	present;	c
	separate;	connate;	n
	terminal	gynobasic	n
stigma(s)	decurrent along the ventral suture of the ovary or ventral surface of the style;	apical, or style stigmatic all around;	n

TABLE 2.—continued.

Character	Primitive state	Derived state	Reversibility
placentas in 2-∞ carpellate pistil	separate	connate	n
	axile;	parietal;	r
	axile;	apical, basal, or free-central;	n
ovules	not enlarged	enlarged and fleshy	r
	few;	∞, or 1 when carpels more than 1;	c
	crassinucellar;	tenuinucellar;	n
fruit	bitegmic	unitegmic	n
	follicle	other types	n
	ventricidal or septicidal	loculicidal	n
dehiscence of capsule	medium-sized	small or large	r
seed	absent	present	r
sarcotesta or aril	small;	large;	r
embryo	straight	curved or variously folded	n
cotyledons	small;	large;	r
	as wide as radicle	wider than radicle	r
radicle	long;	short;	n
	not invested	invested	n
endosperm	copious	scanty or absent	n

study has been of relationships of the families. I intend to consider the relationships of the orders more fully in a future publication.

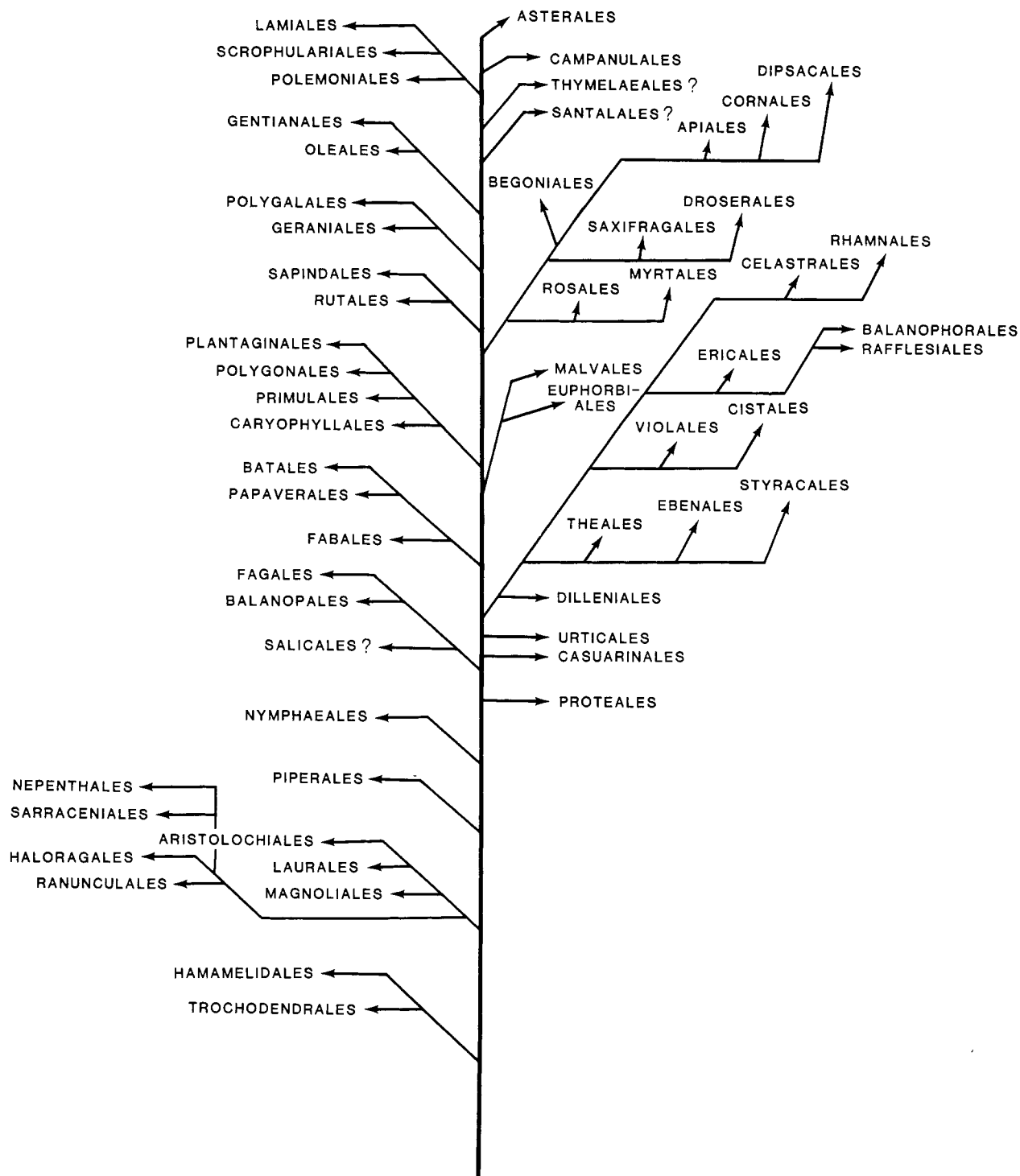
Other families accepted by the above authors, are as follows.

Cronquist, 1981. Barclayaceae in Nymphaeales; Cecropiaceae in Urticales; Oncothecaceae in Theales; Huaceae in Violales; Anisophylleaceae, Alseuosmiaceae, Chrysobalanaceae, Surianaceae, and Rhabdodendraceae in Rosales; Dipentodontaceae, Viscaceae, and Eremolepidaceae in Santalales; Mitrostemaceae in Rafflesiaceae; Hippocrateaceae in Celastrales; Hugoniaceae in Linales; Xanthophyllaceae in Polygalales; Julianiaceae in Sapindales; Retziaceae and Saccifoliaceae in Gentianales; Duckeodendraceae in Solanales; Medonciaceae in Scrophulariales; Pentaphragmataceae and Sphenocleaceae in Campanulales; Tepuianthaceae in Celastrales or Sapindales.

Takhtajan, 1983. Glaucidiaceae in Ranunculales; Cecropiaceae in Urticales; Hectorellaceae in Caryophyllales; Sauvagesiaceae, Oncotheca-

ceae, and Asteropeiaceae in Theales; Dipentodontaceae in Violales; Koeberliniaceae in Caprales; Huaceae in Malvales; Montiniaceae, Roridulaceae, and Alseuosmiaceae in Saxifragales; Chrysobalanaceae in Rosales; Rhabdodendraceae, Nitrariaceae, Kirkiaceae, Ptaeroxylaceae, Julianiaceae, and Podoaceae in Rutales; Stylobasiaceae, Emblingiaceae, and Physenaceae in Sapindales; Aucubaceae, Melanophyllaceae, Griselinaceae, Toricelliaceae, and Helwingiaceae in Cornales; Sphenostemonaceae, Phellinaceae, and Lophopyxidaceae in Celastrales; Viscaceae in Santalales; Cynomoriaceae in Balanophorales; Morinaceae in Dipsacales; Duckeodendraceae, Retziaceae, and Martyniaceae in Scrophulariales.

Thorne, 1983. Glaucidiaceae in Paeoniales; Oncothecaceae, Phellinaceae, and Sphenostemonaceae in Theales; Halophytaceae in Chenopodiales; Ledocarpaceae in Geraniales; Lophopyxidaceae in Celastrales; Eremolepidaceae and Viscaceae in Santalales; Cynomoriaceae in Balanophorales; Dipentodontaceae in Violales; Huaceae and Plagiopteraceae in Malvales; Tepuianth-



Suggested phylogenetic relationships
of the orders of dicotyledons.

thaceae, Ptaeroxylaceae, and Surianaceae in Rutales; Chrysobalanaceae in Rosales; Roridulaceae in Pittosporales; Rhynchocalycaceae and Alzateaceae in Myrtales; Martyniaceae in Bignoniales; Pentaphragmataceae in Campanulales; Aucubaceae in Cornales; Helwingiaceae and Torricelliaceae in Araliales.

Dahlgren, 1983. Kingdoniaceae, and Glaucidaceae(?) in Ranunculales; Halophytaceae and Hectorellaceae in Caryophyllales; Limoniaceae in Plumbaginales; Plagiopteraceae and Huaceae in Malvales; Cecropiaceae in Urticales; Dipentodontaceae in Violales; Oncothecaceae in Theales; Aegicerataceae and Coridaceae in Primulales; Corylaceae in Fagales; Brexiaceae in Saxifragales; Lepuropetalaceae in Droserales; Malaceae, Amygdalaceae, Surianaceae(?), and Rhabdodendraceae(?) in Rosales; Psiloxylaceae, Heteropyxidaceae, Memecylaceae, Rhynchocalycaceae, and Alzateaceae in Myrtales; Chrysobalanaceae in Chrysobalanales; Podoaceae, Emblingiaceae, and Meliosmaceae in Sapindales; Ptaeroxylaceae and Tepuianthaceae in Rutales; Nitrariaceae, Peganaceae, Lepidobotryaceae, Ledocarpaceae, Biebersteiniaceae, and Diracmaceae in Geraniales; Lophopyxidaceae in Celastrales; Eremolepidaceae and Viscaceae in Santalales; Cynomoriaceae in Balanophorales; Pentaphragmataceae and Lobeliaceae in Campanulales; Sclerophyllaceae, Goetzeaceae, and Cobaeaceae in Solanales; Ehretiaceae in Boraginales; Roridulaceae in Ericales; Helwingiaceae, Torricelliaceae, Aucubaceae, Aralidiaceae, Phellinaceae, Sphenostemonaceae, Montiniaceae, Alseuosmiaceae, Anisophylleaceae, Sambucaceae, Viburnaceae, Dulongiaceae(?), and Tribelaceae in Cornales; Triplostegiaceae and Morinaceae in Dipsacales; Desfontainiaceae and Saccifoliaceae in Gentianales; Selaginaceae, Stilbaceae, Retziaceae, Trapellaceae, and Martyniaceae in Scrophulariales.

Emberger, 1960. Cynomoriaceae in Santalales; Sphenocleaceae and Dysphaniaceae in Centrospermales; Julianiaceae in Julianiales; Coriariaceae, Cyrillaceae, and Pentaplastaceae in Terebinthales, with a tendency toward Celastrales; Diclidanthaceae in Terebinthales(?); Hippocra-

teaceae in Celastrales; Humbertiaceae, Selaginaceae, Martyniaceae, and Tetrachondraceae in Tubiflorales; Sarcospermaceae in Ebenales; Lepidobotryaceae in Geraniales; Lophopyxidaceae in Euphorbiales; Lobeliaceae in Synantherales; Chrysobalanaceae and Roridulaceae in Rosales; Heteropyxidaceae in Myrtales.

Hutchinson, 1973. Corylaceae in Fagales; Picrodendraceae in Juglandales; Aquilariaceae in Thymelaeales; Diracmaceae in Tiliales; Huaceae, Ledocarpaceae, and Lepidobotryaceae in Malpighiales; Prionotaceae and Vacciniaceae in Ericales; Anisophylleaceae in Myrtales; Koeberliniaceae and Hippocrateaceae in Celastrales; Dipentodontaceae in Olacales; Heteropyxidaceae in Rhamnales; Aegicerataceae in Myrsinales; Sarcospermataceae in Ebenales; Averrhoaceae in Rutales; Podoonaceae and Julianiaceae in Sapindales; Potaliaceae, Antoniaceae, Spigeliaceae, and Strychnaceae in Loganiales; Periplocaceae in Apocynales; Cobaeaceae and Martyniaceae in Bignoniales; Ehretiaceae, Stilbaceae, and Dicrastylidaceae in Verbenales; Helleboraceae in Ranales; Cleomaceae and Oxystylidaceae in Brassicales; Dysphaniaceae in Chenopodiales; Lobeliaceae in Campanulales; Retziaceae in Solanales; Salpiglossidaceae in Personales; Selaginaceae in Lamiales.

Melchior, 1964. Dipentodontaceae in Santalales; Dysphaniaceae in Centrospermae; Roridulaceae and Chrysobalanaceae in Rosales; Picrodendraceae in Rutales; Julianiaceae in Julianiales; Hippocrateaceae in Celastrales; Cynomoriaceae in Myrtales; Sarcospermataceae in Ebenales; Desfontainiaceae in Gentianales; Duckeodendraceae, Henriqueziaceae, and Martyniaceae in Tubiflorae; Sphenocleaceae and Pentaphragmataceae in Campanulales.

Stebbins, 1974. Alseuosmiaceae(?) and Chrysobalanaceae in Rosales; Dipentodontaceae(?) and Cynomoriaceae in Santalales; Hippocrateaceae in Celastrales; Julianiaceae in Sapindales; Sphenocleaceae in Campanulales.

Rouleau, 1981. Sphenostemonaceae, Siparunaceae, Atherospermataceae, and Gyrocarpaceae in Laurales; Peperomiaceae in Piperales; Eury-

alaceae and Barclayaceae in Nymphaeales; Kingdoniaceae, Glaucidiaceae, Hydrastidaceae, and Leonticeae in Ranunculales; Pteridophyllaceae and Hypecoaceae in Papaverales; Rhodoleiaceae and Altingiaceae in Hammeliales; Celtidaceae in Urticales; Carpinaceae and Corylaceae in Betulales; Tetragoniaceae, Halophytaceae, Hectorellaceae, and Dysphaniaceae in Caryophyllales; Aegialitidaceae and Limoniaceae in Plumbaginales; Lophiraceae, Sladeniaceae, Asteropeiaceae, and Oncothecaceae in Theales; Neumanziaceae in Violales; Tetramelaceae in Begoniales; Cleomaceae, Koeberliniaceae, Canotiaceae, and Emblingiaceae in Capparales; Populaceae in Salicales; Vacciniaceae in Ericales; Sarcospermataceae and Boerlagellaceae in Ebenales; Coridaceae in Primulales; Huaceae in Malvales; Stylocerataceae, Androstachydaceae, Bischofiaceae, Hymenocardiaceae, Peraceae, and Picrodendraceae in Euphorbiales; Tribelaceae, Brexiaceae, Dulongiaceae, Montiniaceae, Roridulaceae, Penthoraceae, and Lepuropetalaceae in Saxifragales; Chrysobalanaceae in Rosales; Anisophylleaceae, Napoleonaceae, Foetidaceae, Heteropyxidaceae, Psiloxylaceae, and Memecylaceae in Myrtales; Myriophyllaceae in Hippuridales; Uapacaceae, Pistaciaceae, Blepharocaryaceae, Julianiaceae, Podoaceae, Surianaceae, Stylobasiaceae, Rhabdodendraceae, Flindersiaceae, Ptaeroxylaceae, Kirkiaceae, and Aitoniaceae in Rutales; Physenaceae and Meliosmaceae in Sapindales; Hugoniaceae, Lepidobotryaceae, Nitrariaceae, Peganaceae, Averrhoaceae, Hypseocharitaceae, Ledocarpaceae, Dirachmaceae, and Biebersteinaceae in Geraniales; Xanthophyllaceae in Polygalales; Aucubaceae, Curtisiaceae, Griselinaceae, Melanophyllaceae, Mastixiaceae, Helwingiaceae, and Toricelliaceae in Cornales; Hydrocotylaceae in Apiales; Phellinaceae, Stilaginaceae, Lophopyxidaceae, and Hippocrateaceae in Celastrales; Schoepfiaceae, Dipentodontaceae, Viscaceae, and Eremolepidaceae in Santalales; Cynomoriaceae in Balanophorales; Carlemanniaceae, Sambucaceae, Alseuosmiaceae, Morinaceae, and Triplostegiaceae in Dipsacales; Desfontainiaceae, Spigeliaceae, Strychnaceae,

Antoniaceae, Potaliaceae, Periplocaceae, Naucleaceae, and Henriqueziaceae in Gentianales; Cobaeaceae and Humbertiaceae in Polemoniales; Ehretiaceae and Wellstediaceae in Boraginales; Goetzeaceae, Duckeodendraceae, Retziaceae, Ellisophyllaceae, Trapellaceae, Martyniaceae, Mendonciaceae, and Thunbergiaceae in Scrophulariales; Avicenniaceae, Symphoremataceae, Dicrastylidaceae, Plagiopteraceae, Stilbaceae, and Tetrachondraceae in Lamiales; Pentaphragmataceae, Lobeliaceae, and Sphenocleaceae in Campanulales.

D. Young, 1981. Glaucidiaceae and Hydrastidaceae in Ranunculales; Phellinaceae, Oncothecaceae, and Sphenostemonaceae in Theales; Hectorellaceae in Caryophyllales; Gisekiaceae and Halophytaceae in Chenopodiales; Huaceae and Plagiopteraceae in Malvales; Cecropiaceae in Urticales; Dipentodontaceae in Violales; Hippuridaceae and Lophopyxidaceae in Celastrales; Eremolepidaceae and Viscaceae in Santalales; Cynomoriaceae in Balanophorales; Ptaeroxylaceae in Rutales; Surianaceae in Sapindales; Chrysobalanaceae in Rosales; Penthoraceae and Brexiaceae in Saxifragales; Montiniaceae, Tribelaceae, Alseuosmiaceae, and Phyllonomaceae in Hydrangeales; Roridulaceae in Pittosporales; Martyniaceae in Bignoniales; Pentaphragmataceae in Campanulales; Sambucaceae in Dipsacales.

Benson, 1979. Koeberliniaceae in Papaverales; Julianiaceae and Hippocrateaceae in Sapindales; Martyniaceae in Scrophulariales; Cynomoriaceae in Santalales; Dipentodontaceae(?); Huaceae(?).

Ordinal and Family Descriptions

TROCHODENDRALES

Usually trees, sometimes shrubs; xylem vesselless and tracheids long, or vessel perforation plates scalariform with many bars; leaves usually alternate, crenate, exstipulate or the stipules adnate to the petiole; buds perulate; plants dioecious or the flowers bisexual; flowers minute, anemophilous or rarely entomophilous; sepals 0

or 4; petals 0; stamens 4–40, in 1, 3 or 4 series, rarely adnate to the ovary, the filaments filiform, anthers oblong-linear, basifixed, the connective often produced apically; pollen 3-colpate, 3(4)-colporoidate; pistils 4–18, in 1 whorl, or pistil 1 and 4–11-carpellate, the styles as many as carpels, stigmas decurrent ventrally; ovary superior, 4–11-locular in the compound pistils, the ovules 1 or several to numerous; fruit follicular or a capsule dehiscing along the ventral sutures, or small samaras; seeds small, the embryo usually small; endosperm usually copious.

Distribution: Mainly temperate China and Japan.

Chemistry: Hegnauer considers that lack of oil-cells and presence of myricetin and ellagic acid support placing Cercidiphyllaceae near Hamamelidaceae. The presence of leucodelphinidin and a large number of free triterpene alcohols, aldehydes and acids in *Trochodendron* is not a very good indication of relation to Magnoliales. Trochodendraceae, Cercidiphyllaceae, Tetracentraceae, and Eupteleaceae do not contain alkaloids nor lignans, whereas both of these are common in Magnoliales.

CERCIDIPHYLLACEAE (Figure 1a).—Trees with long and short shoots; xylem vessel perforation plates scalariform, with 20–50 very fine bars; leaves simple, deciduous, opposite and alternate, crenate, the main veins palmately arranged, stipules adnate to the petiole; inflorescence axillary fascicles of 1–6 flowers, the plants dioecious; sepals 4, small, also interpreted as bracts; petals 0; stamens 8–20, the filaments long, filiform; anthers oblong-linear, basifixed; pollen 3-colp(oid)ate; pistils usually 4–6, the style filiform, stigma decurrent ventrally, long; ovules numerous, marginal, biseriate, with subchalazal process, bitegmic, crassinucellar, anatropous; fruits follicular, the seeds small, numerous, compressed, winged; embryo medium-sized to large, spatulate, straight, as long as the endosperm, the cotyledons elliptic, flat, moderately thick, as wide as, to twice as wide as, the radicle, 0.5 times the length of the embryo; endosperm moderate, fleshy.

Composition: 1 genus, 1 species.

Distribution: Japan, northeastern China to Korea.

TETRACENTRACEAE (Figure 1b–e).—Trees with long and short shoots; xylem vesselless, the tracheids extremely long, the parenchyma diffuse; leaves simple, deciduous, alternate, crenate, the main veins palmately arranged; bud enclosed by stipule adnate to the petiole; inflorescence a catkin-like spike, the flowers in groups of 4, bisexual; sepals 4, small; petals 0; stamens 4, hypogynous, the filaments filiform; anthers as long as wide, basifixed; pollen 3-colp(oroid)ate; pistil 1, carpels 4, united at ovary level, styles 4, free, filiform, stigmas decurrent ventrally; ovary superior, locules 4, ovules several per locule, axile with subchalazal process, bitegmic, crassinucellar, anatropous; fruit a follicetum, each carpel dehiscing ventrally; seeds minute, fusiform, the embryo minute, subglobular or ellipsoid, obscurely cleft at the apex, 0.07 the length of the endosperm; endosperm copious, oily.

Composition: 1 genus, 1 species.

Distribution: Central and southwestern China, Nepal, northern Burma.

EUPTELEACEAE (Figure 2a,b).—Trees or shrubs; xylem vessel perforation plates scalariform, with 20–90 bars; leaves simple, deciduous, alternate, serrate, exstipulate, the buds perulate; inflorescence a fascicle of 6–12 flowers in axils of bracts; flowers bisexual; perianth absent; stamens about 10 in 1 whorl, the filaments filiform; anther oblong, long, basifixed, the connective produced apically; pollen 3-colpate; pistils 6–18 in 1 whorl, not completely closed, the ovules 1–3, ventral, bitegmic, crassinucellar, anatropous; stigma sessile, ventral; fruitlets small samaras; embryo small, straight, 0.5 the length of the endosperm; cotyledons as wide as the radicle, 0.6 the length of the embryo; endosperm copious, oily.

Composition: 1 genus, 2 species.

Distribution: Central and southwestern China, Assam, Japan.

TROCHODENDRACEAE (Figure 2c,d).—Trees, the bark and foliage slightly aromatic (?); xylem

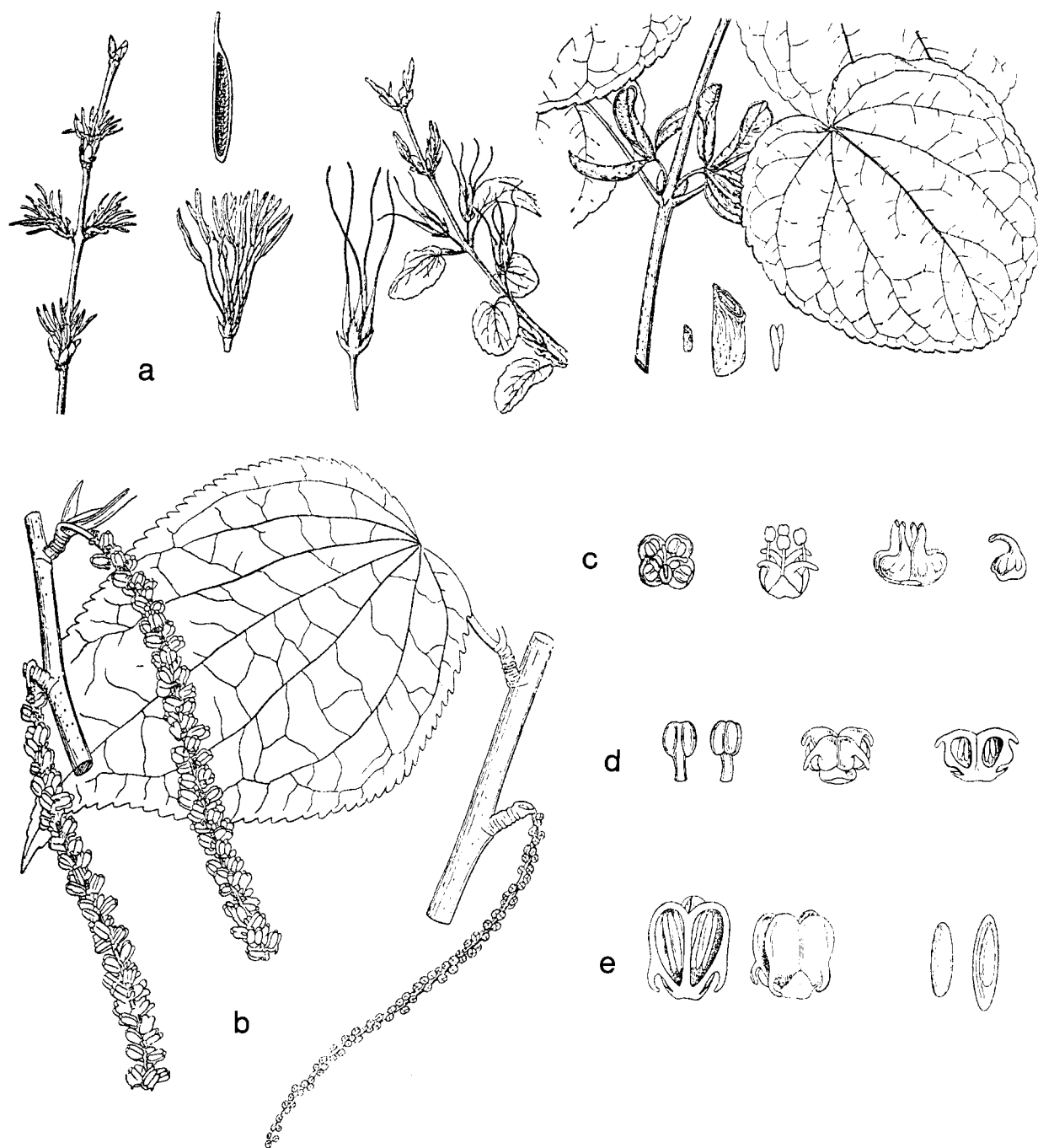


FIGURE 1.—CERCIDIPHYLLACEAE: *a*, *Cercidiphyllum japonicum* ♂ flowering twig, l.s. of pistil, ♂ flower, ♀ flower, ♀ flowering twig, twig with dehiscent fruitlets, seed, l.s. of same showing the embryo, embryo (after Sargent). TETRACENTRACEAE: *b*, *Tetracentron sinensis* twig with 2 inflorescences at anthesis, twig with inflorescence in bud; *c*, bud laid open, flower, pistil, carpel; *d*, views of anther, pistil more advanced, l.s. of same; *e*, l.s. of fruit, fruit, seed with testa removed, seed (after Oliver).

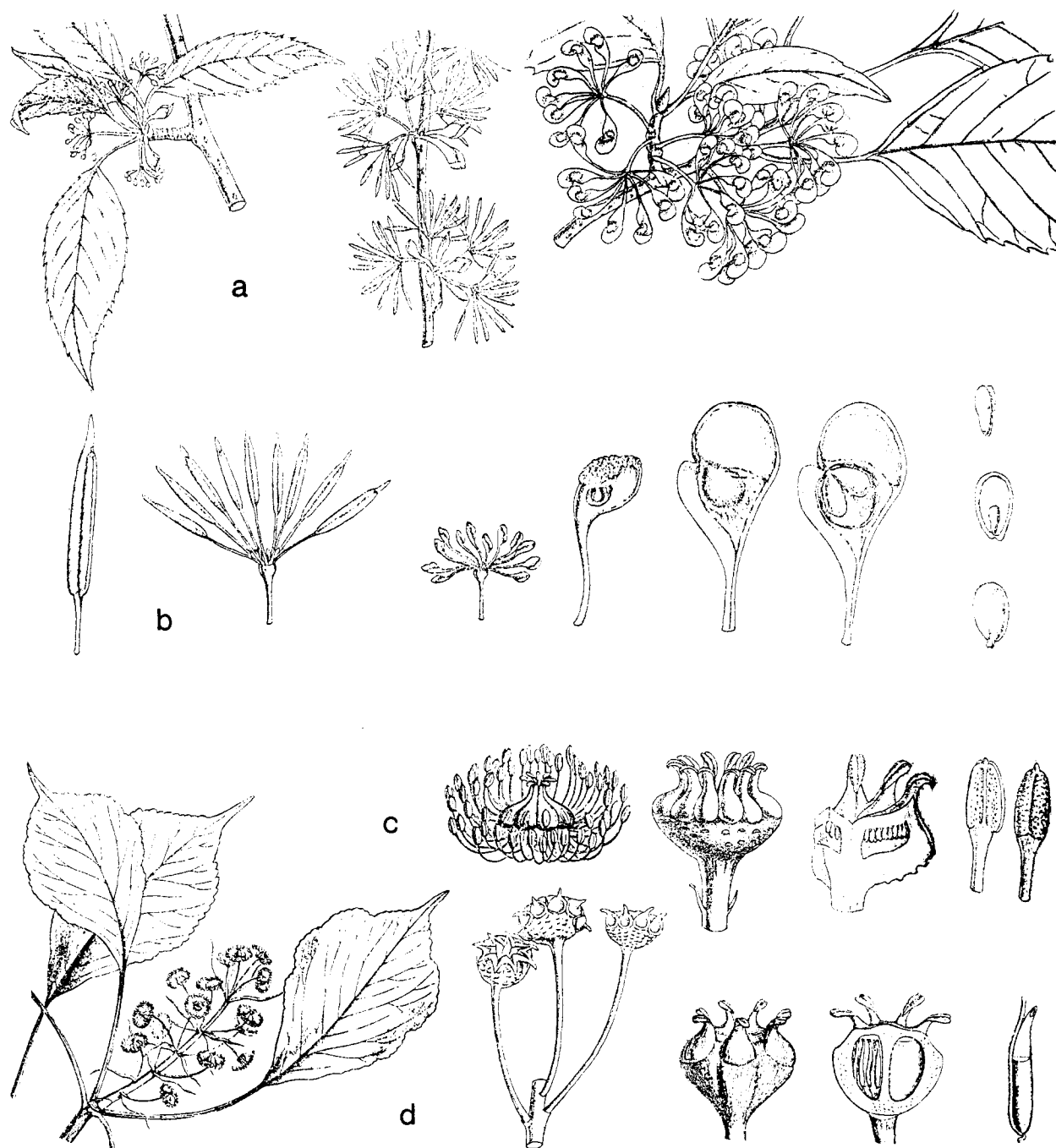


FIGURE 2.—EUPTELEACEAE: *a*, *Euptelea davidiana* twig with ♀ flowers, parts of a twig with ♂ flowers in clusters of four, twig in fruit; *b*, stamen, ♂ flower, ♀ flower, l.s. of one of the pistils, fruitlet, l.s. of a fruitlet, seed, l.s. of same, embryo (after Hemsley). TROCHODENDRACEAE: *c*, *Trochodendron aralioides* flower, pistil, l.s. of a carpel, views of anther after and before dehiscence, twig with inflorescence; *d*, dehiscent fruits, fruit, l.s. of same showing seeds, section of a seed showing minute embryo (after Hooker and Hooker, 1837–1982; Prantl).

vesselless, the tracheids long, the parenchyma diffuse; leaves alternate, simple, coriaceous, persistent, subverticillate, crenate-serrate, venation pinnate, exstipulate, the buds perulate; inflorescence a terminal racemiform pleiochasial cyme; flowers bisexual; perianth absent; stamens 20–40, 3–4-seriate, adnate to the ovary, the filaments filiform; anthers twice as long as wide, adnate; pollen 3(–4)-colporoidate; pistil 1, the carpels (4–) 6–11, laterally connate in 1 whorl, the styles 4–11, short, the stigmas decurrent ventrally; ovary locules 4–11; ovules ventral, with subchalazal process, bitegmic, crassinucellar, anatropous, about 18 per locule; a droplet of fluid is secreted from the dorsal protuberance of each carpel; fruit a capsule, the carpels dehiscent ventrally and partly septicidally; seeds minute, fusiform, produced at each end; embryo minute, undifferentiated, 0.1 the length of the endosperm; endosperm copious, oily.

Composition: 1 genus, 1 species.

Distribution: Japan, Taiwan, Korea; at altitudes of 666–3000 m.

HAMAMELIDALES

Trees and shrubs; xylem vessel perforation plates entirely or mostly scalariform, usually with more than 20 bars; leaves usually alternate, toothed or entire, stipulate or exstipulate; plants dioecious or monoecious, less commonly the flowers bisexual; flowers minute or small, anemophilous or entomophilous; sepals 0 or 4–8; petals usually 0, sometimes 4–5 (–7); stamens 2–14 (–32), the filaments usually short, anthers adnate or basifixed, the connective sometimes apically produced; pollen 3-colpate, –colporate, –colporoidate or polyforate, rarely 4-ruptate or 6-rugate; pistils usually 1, rarely 5–9, the styles as many as carpels, stigma usually decurrent ventrally; ovary 2–3 (4)-locular in the compound pistils, the ovules 1–many per locule, axile, rarely parietal; fruit follicles, loculicidal or septicidal capsule, nutlet or drupe; seeds 1–many, the embryo minute to as long as the endosperm; endosperm copious to absent.

Distribution: Often in eastern Asia, also in Africa and North America, some reaching northern South America, in various habitats.

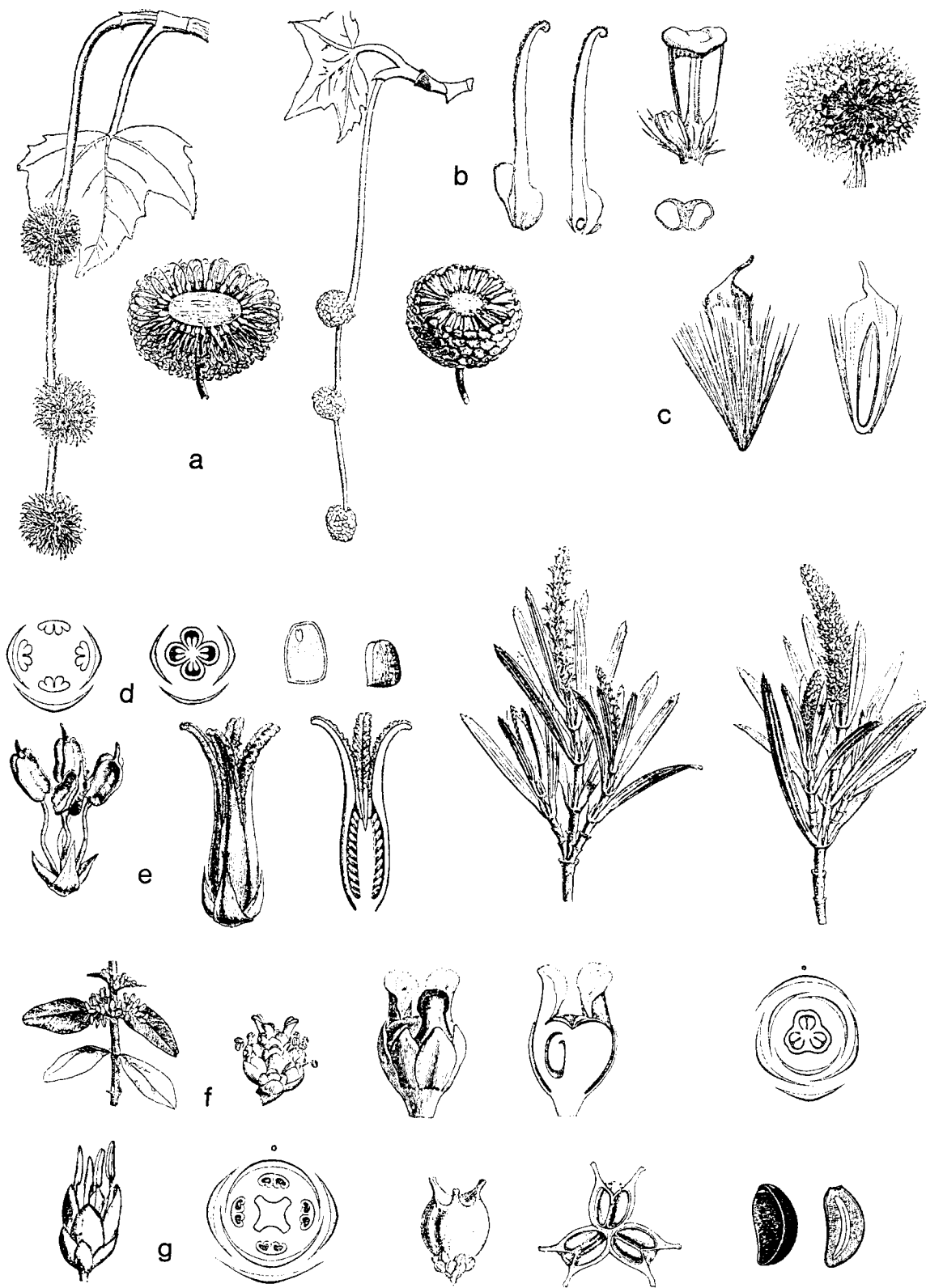
Chemistry: According to Jay, *Hamamelis*, *Myrothamnus*, and *Platanus* are chemically related and related to Saxifragaceae, and *Myrothamnus* leaf pigments are identical to those of *Disanthus*. Platanaceae are highly cyanogenic.

PLATANACEAE (Figure 3a–c).—Trees, often with segments of bark scaling off; xylem vessel perforation plates scalariform with fewer than 20 bars, and simple; leaves simple, deciduous, alternate, dentate, usually palmately rarely pinnately veined, usually lobed, the petiole base capping the bud; stipules usually large and broad and united around the twig; inflorescences globular heads, the peduncle pendulous, the plants monoecious; perianth represented by minute scales; stamens 3–7, the filaments short; anthers adnate, apical connective flattened horizontally; pollen usually 3-colpate or –colporate; pistils mostly 5–9, not completely closed apically, the style elongated, stigma decurrent ventrally; ovules 1 (–2), bitegmic, crassinucellar, orthotropous; fruit an obconical nutlet surrounded at the base by long hairs; embryo linear, terete, straight, as long as the endosperm; cotyledons thin, 0.5 the length of the embryo; endosperm scanty, fleshy.

Composition: 1 genus, 7 species.

Distribution: Eastern and southwestern United States, Mexico; part of temperate eastern Canada; southeastern Europe to northern Iran; Himalayas; Indochina.

MYROTHAMNACEAE (Figure 3d,e).—Low resinous shrubs; xylem vessel perforation plates mostly scalariform with about 45 bars; leaves simple, small, opposite, flabellate-cuneate, plicate-veined, the stipules attached to the petiole; inflorescence terminal and axillary erect catkin-like spikes, the plants dioecious; perianth 0; stamens 4–8 subtended by a bract, the filament short; anthers large, basifixed, the connective produced apically; pollen faintly 3-colpoid; pistil 1, the carpels 3 (–4), the styles 3, recurved, stigma decurrent ventrally; ovary superior, 3-locular, the ovules numerous, axile; fruits dehiscent.



ing septicidally and ventrally into 3 follicles, the seeds numerous, minute; embryo minute, 0.3 the length of the endosperm; cotyledons not broadened(?), 0.3 the length of the embryo; endosperm copious.

Composition: 1 genus, 2 species.

Distribution: Often in arid areas; tropical and southern Africa, Madagascar.

BUXACEAE (Figure 3*f,g*).—Trees and shrubs, rarely subshrubs; xylem vessel perforation plates usually exclusively scalariform with 30 or more bars; leaves simple, evergreen, mostly entire, opposite or alternate, exstipulate; inflorescences mostly axillary dense racemes, spikes, or the flowers solitary, the ♀ flowers fewer than the ♂, the plants monoecious or dioecious; sepals usually 4 or 6, in 2 whorls, basally connate, sometimes 0; petals 0; stamens 4 or 6 (to 30 in *Styloceras*); anthers oblong, basifixed, dehiscing by valves or longitudinally; pollen usually polyforate; pistil 1, the carpels 3 (2–4), styles 3 (2–4), sometimes distant, persistent, the stigmas decurrent ventrally; ovary superior, locules 3 (2–4), the ovules 1–2 per locule, axile, bitegmic, crassinucellar, anatropous; fruit a loculicidal capsule sometimes dehiscing explosively, or drupe; seeds usually black and shiny, sometimes with a caruncle; embryo straight, linear, terete, small to large, 0.2–0.9 the length of the endosperm; cotyledons 0.1–0.8 the length of the embryo, 4 times wider than the radicle; endosperm copious, fleshy.

FIGURE 3.—PLATANACEAE: *a*, *Platanus* sp. ♀ inflorescence, *P. vulgaris* c.s. of ♀ inflorescence, *Platanus* sp. ♂ inflorescence, *P. vulgaris* c.s. of ♂ inflorescence; *b*, *Platanus* sp. ♀ flower, l.s. of pistil, ♂ flower and c.s. anther, *P. vulgaris* infructescence with several fruits removed; *c*, *Platanus* sp. fruit, l.s. of same (after Baillon 1866–1895; Le Maout and Decaisne, 1873). MYROTHAMNACEAE: *d*, *Myrothamnus moschata* diagrams of ♂ and ♀ flowers, *M. flabellifolius* l.s. of seed showing minute embryo, seed; *e*, *M. moschata* ♂ flower, ♀ flower, l.s. of pistil, branch with ♀ inflorescences, branch with ♂ inflorescences (after Baillon, Welwitsch). BUXACEAE: *f*, *Buxus sempervirens* flowering twig, inflorescence, ♀ flower, l.s. of same, diagram of ♀ flower; *g*, ♂ flower, diagram of ♂ flower, young fruit and remains of ♂ flowers, dehiscent fruit, seed, l.s. of same (after Baillon, 1866–1895; Le Maout and Decaisne, 1873).

Composition: 5 genera, ~80 species.

Distribution: Disjunct; temperate to tropical; Europe to India, China, Japan, and the western East Indies; tropical and subtropical southern Africa; southeastern United States; southern Mexico; West Indies; northern Andes.

HAMAMELIDACEAE (Figure 4*a–e*).—Trees or shrubs; xylem vessel perforation plates scalariform, with more than 20 bars; leaves simple, alternate, rarely opposite, deciduous or evergreen, often with stellate indument, sublobed, dentate or entire, the teeth sometimes glandular, stipulate (except *Rhodoleia*); inflorescence an axillary rarely terminal spike or head, rarely raceme; flowers bisexual or the plants polygamous, monoecious or dioecious; sepals 4–5 (0, 6, 7), sometimes connate, rarely calyptrate, usually ± adnate to the ovary; petals 4–5 (0, 6, 7), free, often ligulate, usually perigynous or epigynous; stamens 4–5 (–32), usually perigynous; anthers basifixed, dehiscing lengthwise or by valves, the connective often apically produced; pollen usually 3-colpate or 3-colporoidate or polyforate (occasionally 4-rupate or 6-rugate); glandular disk sometimes present between the stamens and ovary; pistil 1, the carpels 2 (exceptionally a flower may have 1 or 3 carpels), styles free, usually elongate, rarely 0 (*Mytilaria*), filiform, the stigma punctate, capitate or foliar, sometimes decurrent ventrally; ovary semi-inferior, inferior, rarely superior, bilocular, rarely unilocular, the ovules 1–several per locule, axile, rarely parietal, bitegmic, crassinucellar, anatropous; fruit usually a woody capsule, loculicidal or septicidal; embryo straight, 0.6 to as long as the endosperm; cotyledons thin, 2.2–4.0 times as wide as the radicle, 0.6–0.8 the length of the embryo; endosperm moderate or scanty, fleshy.

Composition: 22 genera, ~90 species.

Distribution: Disjunct, chiefly subtropical and warm temperate, centered in eastern Asia; eastern North America to Andes of Venezuela and Bolivia; Japan, China, northeastern India, Indochina; East Indies; southwestern Asia; eastern and southern Africa, Madagascar; northeastern Australia.



FIGURE 4.—HAMAMELIDACEAE: *a*, *Liquidambar styraciflua* twig with ♂ and ♀ inflorescences, l.s. of ♂ inflorescence, c.s. of same, anther, c.s. of ♀ inflorescence; *b*, part of same enlarged, stigmas and staminodes, l.s. of ovary, dehiscent infructescence, seed, l.s. of same, embryo; *c*, *Hamamelis virginiana* flowering and fruiting twigs, floral diagram; *d*, twig with flowers in winter, seed, l.s. of same, embryo; *e*, l.s. of flower, pistil, views of stamen, one with an open anther, staminode, c.s. of fruit, dehiscent fruit (after Baillon, 1866–1895; Le Maout and Decaisne 1873; Sargent).

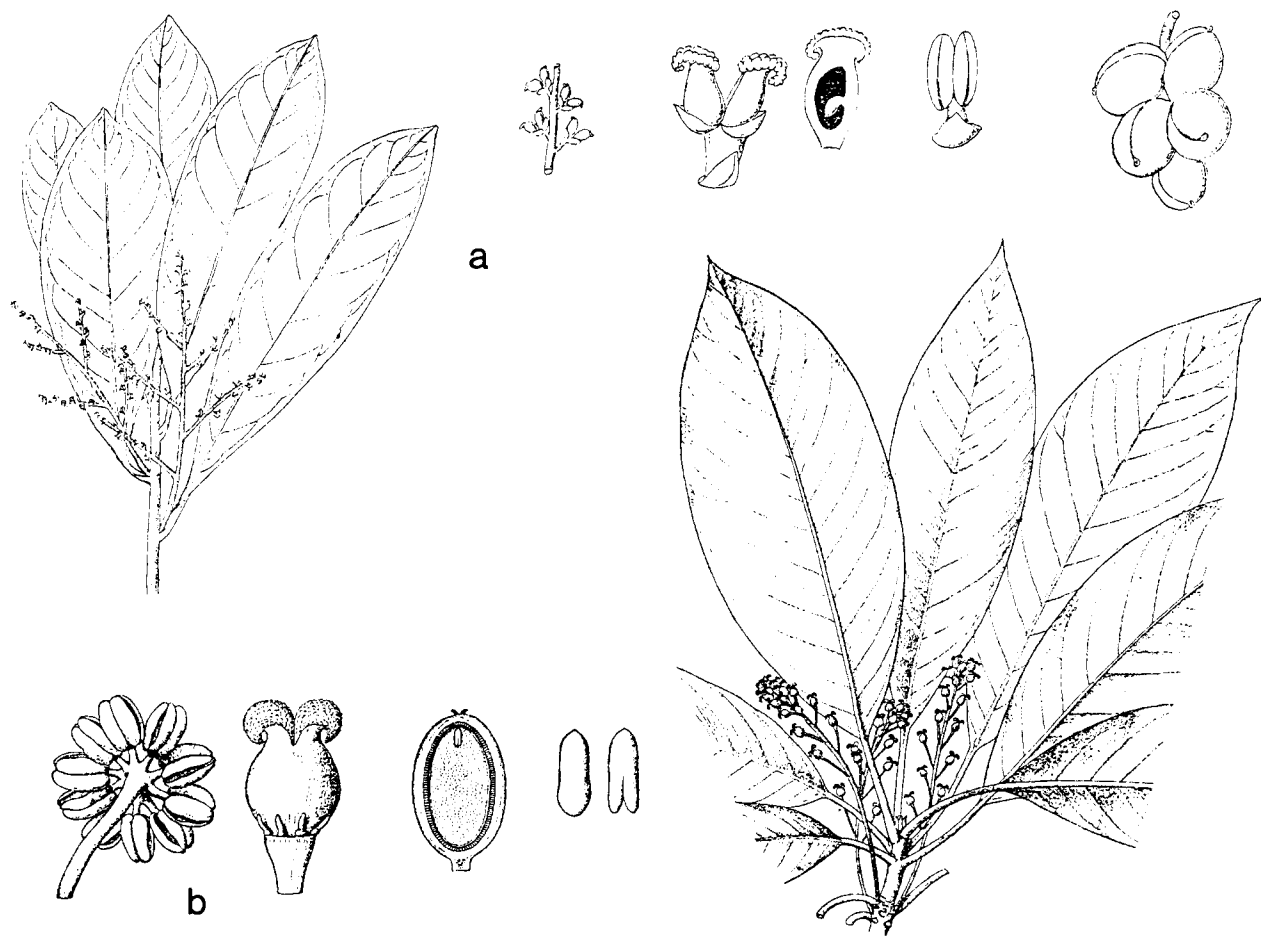


FIGURE 5.—DIDYMELACEAE: *a*, *Didymeles madagascarensis* twig with ♂ inflorescences, part of ♀ inflorescence, two ♀ flowers, l.s. of pistil, ♂ flower, fruits (after Hutchinson, 1973). DAPHNIPHYLLACEAE: *b*, *Daphniphyllum macropodium* ♂ flower, ♀ flower, l.s. of fruit, views of embryo, twig with ♀ inflorescences (after Rosenthal).

DAPHNIPHYLLACEAE (Figure 5*b*).—Trees and shrubs, sometimes containing very poisonous alkaloids; xylem vessel perforation plates scalariform with more than 20 bars; leaves alternate, often subverticillate, rarely opposite, simple, entire or infrequently lobed or toothed near the apex, exstipulate; plants dioecious, rarely polygamodioecious; inflorescences axillary racemes, sometimes partly umbelliform, the flowers minute; sepals 0 or 3–8, free or connate, imbricate; petals 0; stamens 6–14, free, the filaments short, rarely long; anthers introrse or extrorse, oblongish, rarely as long as wide, adnate or basifixed, the connective considerable between the

sacs, and sometimes apically produced; ♀ often with 5–10 staminodes; pollen small, 10–27 μ , 3(–4) colpi(oid)ate; disk 0; pistil 1, the carpels 2 (–4), the styles 1–2 (–4), usually short, stigmas 2 (1–4), divaricate, enlarged, apical or decurrent ventrally; ovary superior, unilocular or incompletely 2(3–4)-locular, the ovules (1) 2 per locule, axile or parietal, subapical, bitegmic, crassinucellar, anatropous; fruit a drupe, the seeds 1 (–2); embryo straight, cylindrical, minute, 0.1 the length of the endosperm; cotyledons not broadened, 0.6 the length of the embryo; endosperm copious, fleshy and oily.

Composition: 1 genus, ~10 species.

Distribution: Japan, China to the Himalayas, Indochina and the western East Indies, western India, Sri Lanka.

DIDYMELACEAE (Figure 5*a*).—Trees; xylem vessel perforation plates scalariform with numerous bars; leaves alternate, simple, entire, smooth, exstipulate; plants dioecious; ♂ inflorescences axillary compound spikes, ♀ in racemes, the flowers in pairs (1–3); sepals (? bracts) 0–4; petals 0; stamens 2, the filaments shorter than the anthers, connate(?); anthers oblongish, basifixed, extrorse; pollen 3-colpate, the colpi 2-orate; pistil 1, unicarpellate, style present or the stigma sessile, apical, somewhat elongated, papillose, grooved so appearing bilobed, persistent in fruit; ovary superior, the ovule 1, semi-anatropous, adaxial; fruit a large drupe, 3.5×1.5 cm., the endocarp osseous, seed bitter; cotyledons large, plano-convex, sometimes connate in age; endosperm 0.

Composition: 1 genus, 2 species.

Distribution: Madagascar.

MAGNOLIALES

Trees and shrubs, sometimes climbers; xylem vessels rarely absent and the tracheids long, vessel perforation plates usually scalariform, often with numerous bars, sometimes simple; leaves usually alternate, entire, less commonly toothed, usually exstipulate; flowers small to large, usually entomophilous, usually bisexual, more rarely the plants monoecious or dioecious, the parts usually hypogynous, rarely perigynous; perianth homo- or heterochlamydeous, rarely absent, the parts spirally arranged and indefinite in number or in 1 or more whorls and fairly frequently 3-merous; stamens usually numerous and spirally arranged, rarely few and whorled, sometimes laminar; staminodes sometimes present; filaments free, rarely connate, the anthers adnate or basifixed, usually longitudinally dehiscent, rarely valvate; pollen usually 1(–3)-sulcate, less frequently 3- or 6-colp(oid)ate, 1- or 8–12-pored, 2-colpate or nonaperturate; pistils many to 1, often spirally arranged, more rarely few or 1 and whorled;

style elongate or the stigma sessile, the stigma frequently decurrent ventrally, more rarely apical, the ovules 1–many; fruits follicles, berries, drupes, achenes, or a fleshy syncarp, rarely a capsule; embryo usually minute; endosperm copious, very rarely scanty or absent.

Distribution: Most frequently in tropical rain forest, less commonly in temperate rain forest or drier forests, especially of eastern Asia and eastern North America.

Chemistry: Magnoliales are rich in characteristic aromatic oils such as monoterpenes and sesquiterpenes. Secretory cells and passages occur in many of the families. They have aromatic aldehydes, mostly phenolic; the Ranunculales lack them. Magnoliales, except Schisandraceae and Illiciaceae, are rich in alkaloids; aporphines are common. They have phenolic esters and ethers, but the Ranunculales lack them. Lignans are disproportionately common in Magnoliales, Ranunculales, Piperales, and Aristolochiales. Calycanthaceae are cyanogenic.

MAGNOLIACEAE (Figure 6*a,b*).—Trees or shrubs; xylem vessel perforation plates typically scalariform with few to 25 bars, more rarely simple; leaves simple, alternate, entire, rarely lobed, the stipules large, enclosing the buds; flowers usually large, usually solitary, terminal or axillary, bisexual (unisexual in *Kmeria*), the parts hypogynous; perianth homiochlamydeous or heterochlamydeous, spirally arranged or in one whorl of sepals and 2–4 of petals, and then usually trimerous (rarely 5-merous); stamens sometimes not differentiated into anther and filament, numerous (~30–50), spirally arranged, free, staminodes 0; anthers generally adnate and oblong, the connective usually apically produced; pollen monosulcate; pistils numerous (~12–60) to 1, spirally arranged on an elongated axis, the stigma decurrent ventrally; ovules 2 to several, bitegmic, crassinucellar, anatropous; fruitlets follicles, samaras, or rarely a fleshy syncarp, or woody capsule (*Pachylarnax*) septicidally or loculicidally dehiscent; seeds usually large, usually with an outer stomate sarcotesta and woody inner integument; embryo minute, 0.2–0.3 the length



FIGURE 6.—MAGNOLIACEAE: *a*, *Magnolia grandiflora* flowering twig, *M. yulan* l.s. of flower, *M. grandiflora* floral diagram; *b*, *Liriodendron tulipifera* two views of anther, fruit, l.s. of same showing minute embryo, *Magnolia yulan* dehiscent fruit, *M. purpurea* l.s. of seed showing minute embryo (after Baillon, 1866–1895; Martius, 1840–1906).

of the endosperm; cotyledons hardly differentiated to 1.5 times wider than the radicle; endosperm copious, fleshy.

Composition: 12 genera, ~225 species.

Distribution: Centered in the Northern Hemisphere; temperate and tropical southeastern Asia from the Himalayas to Japan and the East Indies; eastern United States through Central America to disjunct areas in northern South

America and southeastern Brazil; fossils recovered in Europe and Greenland.

WINTERACEAE (Figure 7a–c).—Trees or shrubs; xylem vessels absent, the tracheids very long; leaves simple, alternate, subverticillate, entire, pellucid-punctate, aromatic, exstipulate; inflorescences subterminal, intercalary or axillary, cymose or fasciculate, or the flowers rarely solitary; flowers small, bisexual, or the plants rarely

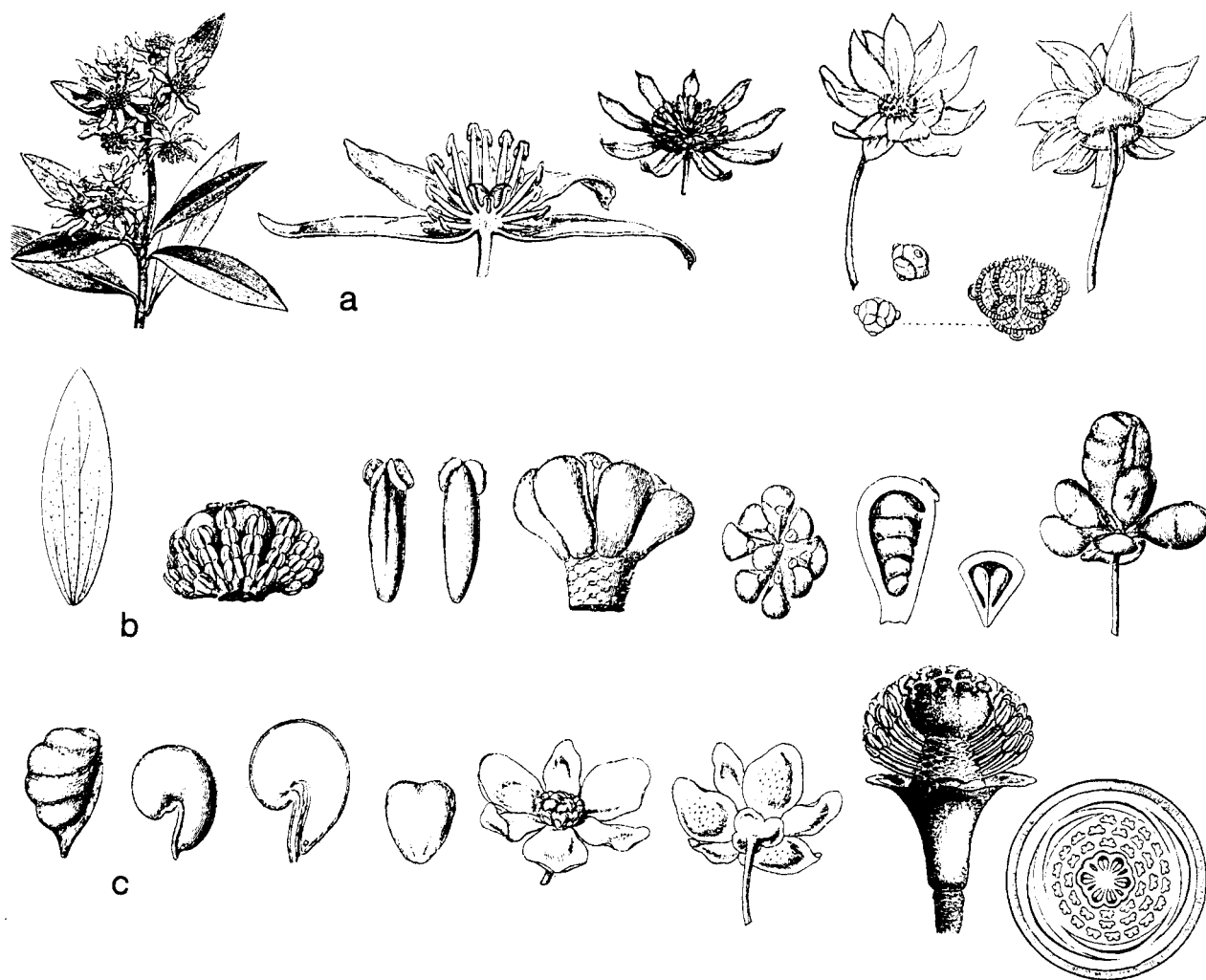


FIGURE 7.—WINTERACEAE: *a*, *Drimys lanceolata* flowering twig, l.s. of flower, ♂ flower, *D. winteri* flower from above and below, pollen grain tetrads; *b*, petal, essential organs from a bud, views of stamen, gynoecium, same from above, l.s. and c.s. of 1 pistil, fruitlets; *c*, single fruitlet, seed, l.s. of same showing the minute embryo, *Pseudowintera axillaris* upper and lower views of flower, *Zygogynum vieillardii* flower with petals removed, floral diagram (after Baillon, 1866–1895; Hooker and Hooker, 1837–1982; Martius, 1840–1906).

polygamous, the parts hypogynous; perianth heterochlamydeous; sepals 2–6 free and valvate or connate and calyptrate enclosing the petals in bud; petals spirally arranged or in 1–4 whorls of 3 or more; stamens 12–250+, spirally arranged, staminodes rare; anthers adnate or basifixed; pollen uniporate (ulcerate; pore usually on distal pole); hypogynous disk rarely present (*Tetralthamus*); pistils 1–24, sometimes incompletely closed, in 1 whorl, sometimes connate (*Zygo-*

gynum), disputedly bicarpellate in *Takhtajania*, style short, stigma(s) decurrent ventrally or apical; ovules 1–85 per pistil, 2-seriate, bitegmic, crassinucellar, anatropous; fruits berries or a fleshy syncarp; embryo minute, not differentiated, 0.04 the length of the endosperm; endosperm copious.

Composition: 7 genera, ~120 species.

Distribution: Wet tropical montane to cool temperate rain forest in disjunct areas in Mexico,

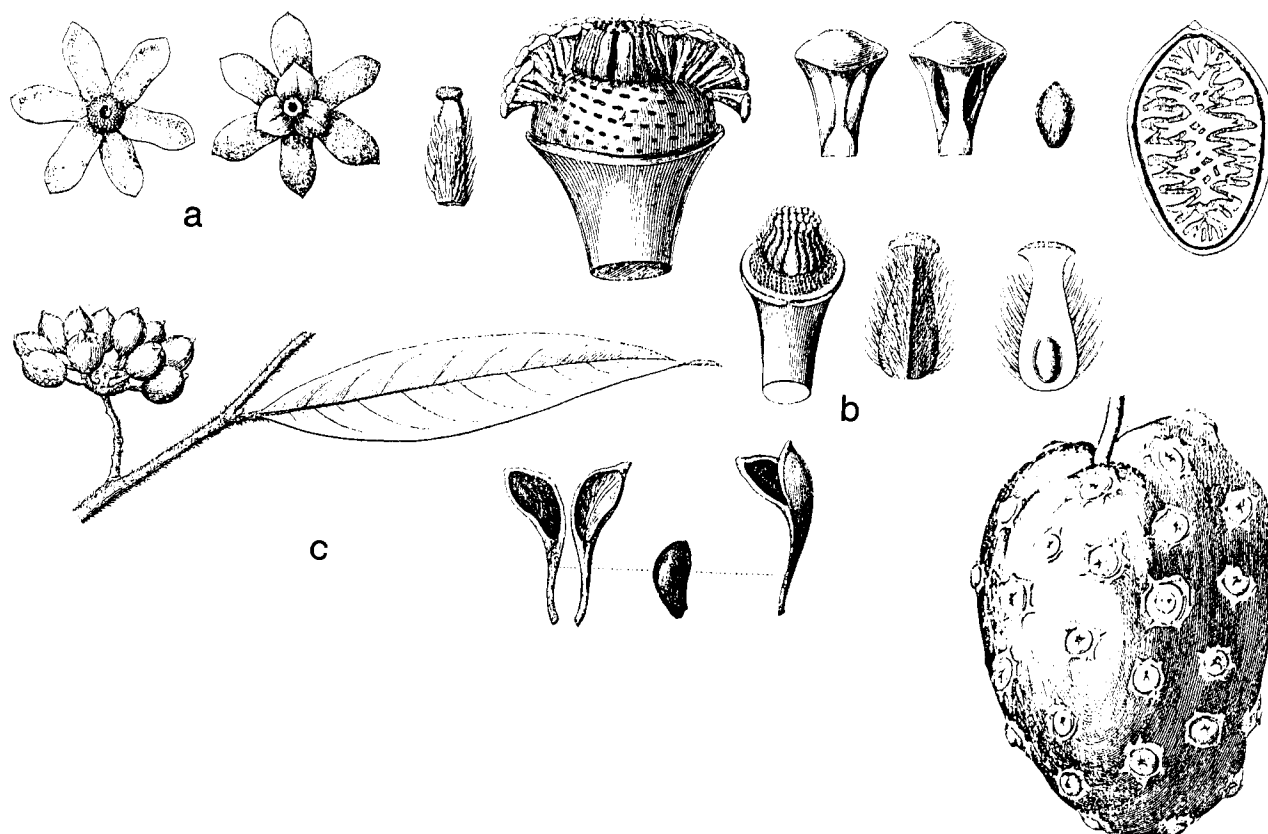


FIGURE 8.—ANNONACEAE: *a*, *Guatteria pohliana* flower from above and below, pistil, pistils and stamens on the convex receptacle, views of stamen, seed, l.s. of same enlarged; *b*, *Rollinia cuspidata* pistils on receptacle, pistil, l.s. of same; *c*, *Guatteria villosissima* fruitlets, *Anaxagorea phaeocarpa* dehiscent fruitlets and seed, *Annona squamosa* fruit (after Martius, 1840–1906).

Central America, northern, eastern, and southern South America, the East Indies, eastern Australia, New Zealand, New Caledonia, Madagascar.

ANNONACEAE (Figure 8a–c).—Trees, shrubs, or climbers; xylem vessel perforation plates simple; leaves simple, alternate, entire, almost always distichous, exstipulate; inflorescence axillary, leaf-opposed or cauliflorous, sympodial, or the flowers solitary; flowers large or small, sometimes smelling like carrion, usually bisexual, rarely the plants monoecious or dioecious (*Stelechocarpus*), the parts hypogynous (stamens perigynous in *Xylopia*); perianth heterochlamydeous; sepals usually 3 (2–4), free or connate, rarely calyptrate; petals often 6 and trimerous, rarely 12, 8, 4, or 3, rarely connate; stamens usually numerous (to

~150), spirally arranged, rarely 3 or 6 and whorled, the filaments very short; subpetaloid staminodes external to the stamens sometimes present (*Fusaea*); anthers usually adnate, sometimes basifixed, usually extrorse, connective usually apically produced and often broad and truncate; pollen nonaperturate or 1-sulcoidate; pistils numerous (to ~25) to 1, spirally arranged (on an elongated torus in *Mischogyne*) or whorled, very rarely open, the styles short or 0 (*Tetrameranthus*), stigmas decurrent to subapical (united in *Piptostigma*, 3-lobed in *Tetrameranthus*); ovary superior, rarely sunk in torus (*Pseudannonia*), unilocular, placentas ventral or parietal, the ovules usually numerous, rarely 1, 2(3)-tegmic, crassinucellar, anatropous; fruits usually berries, often stipitate, sometimes a syncarp, rarely a capsule

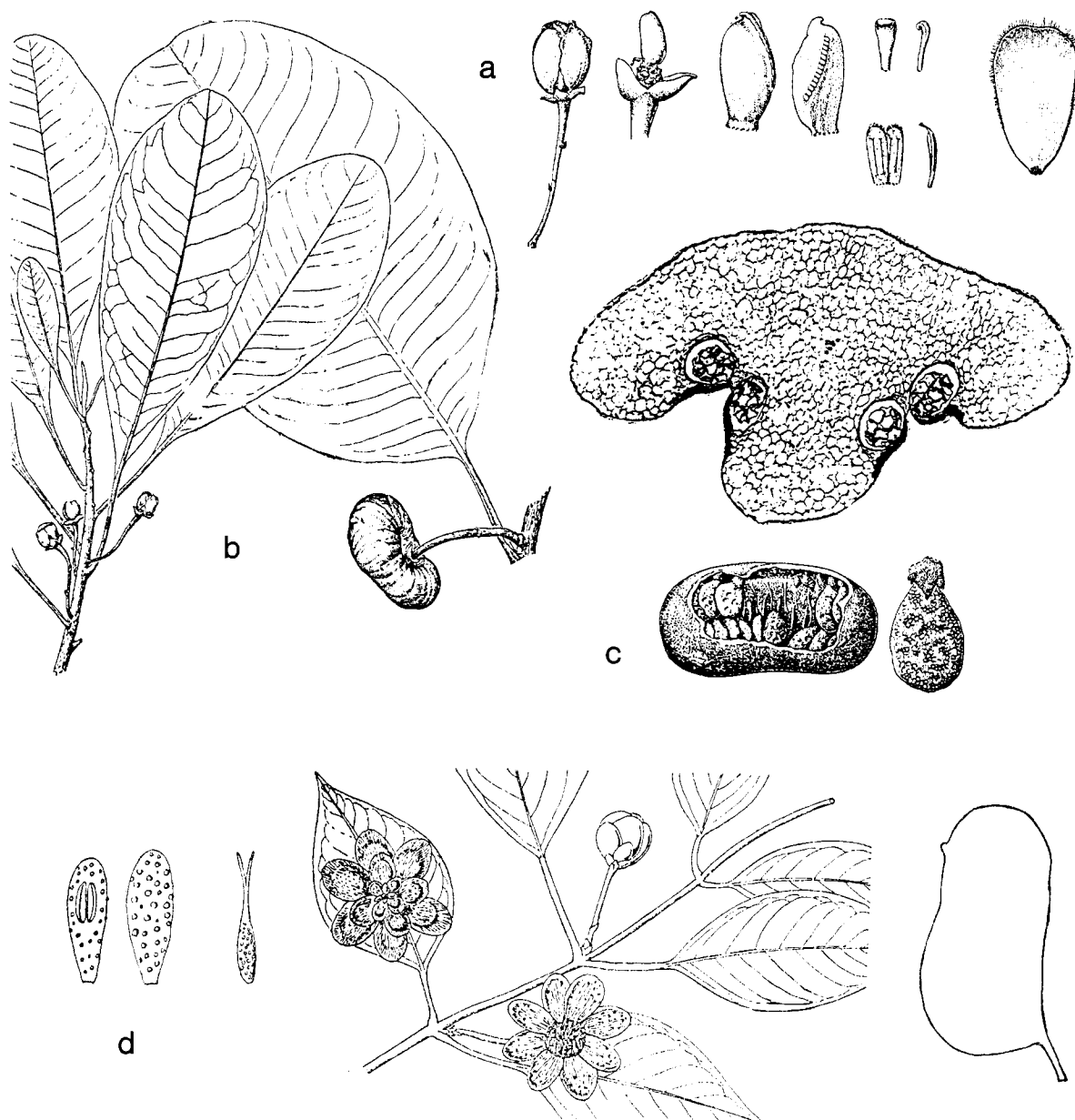


FIGURE 9.—DEGENERIACEAE: *a*, *Degeneria vitiensis* flower, same with petals, stamens and staminodes removed, slightly after anthesis, lateral view of pistil, l.s. of same, views of staminode and stamens, petal; *b*, flowering twig, fruiting twig, c.s. of anther greatly enlarged; *c*, nearly mature fruit with part removed to show seeds, seed with endocarpic appendage (after Bailey and Smith). AUSTROBAILEYACEAE: *d*, *Austrobaileya maculata* views of stamen, a pistil, flower from below, flowering twig, fruitlet (after Hutchinson, 1973; Takhtajan, 1969).

or follicle (*Anaxagorea*), seeds often arillate (winged in *Richella*); embryo minute or small, linear, straight, 0.1–0.3 the length of the endosperm; cotyledons not broadened, undifferen-

tiated or 0.2–0.3 the length of the embryo; endosperm copious, ruminate, hard or fleshy.

Composition: ~120 genera, ~2,000 species.

Distribution: Mostly in lowland evergreen

forest; tropical America; southeast Asia to the East Indies and northern Australia; Africa; few species in temperate America and Asia.

DEGENERIACEAE (Figure 9a-c).—Tree; xylem vessel perforation plates scalariform with numerous bars; leaves simple, alternate, entire, exstipulate; flowers bisexual, solitary, supra-axillary, the parts hypogynous; perianth heterochlamydeous, whorled; sepals 3(-4), persistent; petals 12-18 in 3-5 whorls, fleshy; stamens 20-30, flat, in 3 whorls, not differentiated into anther and filament, anther sacs immersed, linear, extrorse, about 9 staminodes present; pollen 1-sulcate; pistil 1(-2) unicarpellate, open, the stigma sessile, decurrent along the ventral suture of the ovary, the placenta subventral, the ovules numerous, bitegmic, crassinucellar, anatropous; fruit large, leathery, dehiscent along the ventral suture, the seeds large, strongly flattened, with a sarcotesta; embryo minute, 0.02 the length of the endosperm; cotyledons 3 (-4), 0.55 the width of the radicle, 0.4 the length of the embryo; endosperm copious, ruminant, oily.

Composition: 1 genus, 1 species.

Distribution: Fiji.

AUSTROBAILEYACEAE (Figure 9d).—Climbing shrubs, xylem perforation plates scalariform, sieve tube companion cells sparse or absent; leaves simple, opposite, subopposite or alternate, leathery, entire, the stipules small; inflorescence axillary or terminal, the flowers solitary or in cymes of 3 flowers; flowers medium to large, bisexual, smelling of dead fish, the parts hypogynous; tepals 19-24, spirally arranged, pale green, free, with gradual transition from tepals to stamens and staminodes; stamens 7-11, laminar, covered with resinous warts, anther sacs adnate, introrse, staminodes 9-16, internal to the stamens; pollen 1-sulcate; pistils shorter than the staminodes, 6-14, incompletely closed, styles apically bilobed, stigmas decurrent ventrally; ovules 6-8 (4-14) per pistil, bitegmic, crassinucellar, anatropous; fruitlets large, slightly elongated, stipitate berries; seeds about 6, the embryo minute, 0.1 the length of the endosperm, the cotyledons 0.4 the length of the embryo; endosperm copious, ruminant, starchy.

Composition: 1 genus, 2 species.

Distribution: Rain forest of Queensland, Australia.

HIMANTANDRACEAE (Figure 10a,b).—Trees; xylem vessel perforation plates simple and scalariform; leaves simple, alternate, entire, pellucid-punctate, exstipulate, indument of peltate scales; flowers solitary or paired, on short axillary branches, bisexual, the parts hypogynous; sepals 2, connate, calyptrate; petals about 4-7, lanceolate, similar to the stamens; stamens about 40, the anther loculi extrorse, separate and adnate near the base of the elongated filament, staminodes present; pollen 1-sulcate; pistils 7-10 (to ~25), spirally arranged, free except at the base, style elongated, papillose; ovule 1 (-2) per pistil, ventral; fruit a globose, red, fleshy syncarp, the seeds suborbicular, 3-4 mm in diameter; embryo small, endosperm copious, oily.

Composition: 1 genus, 2 species.

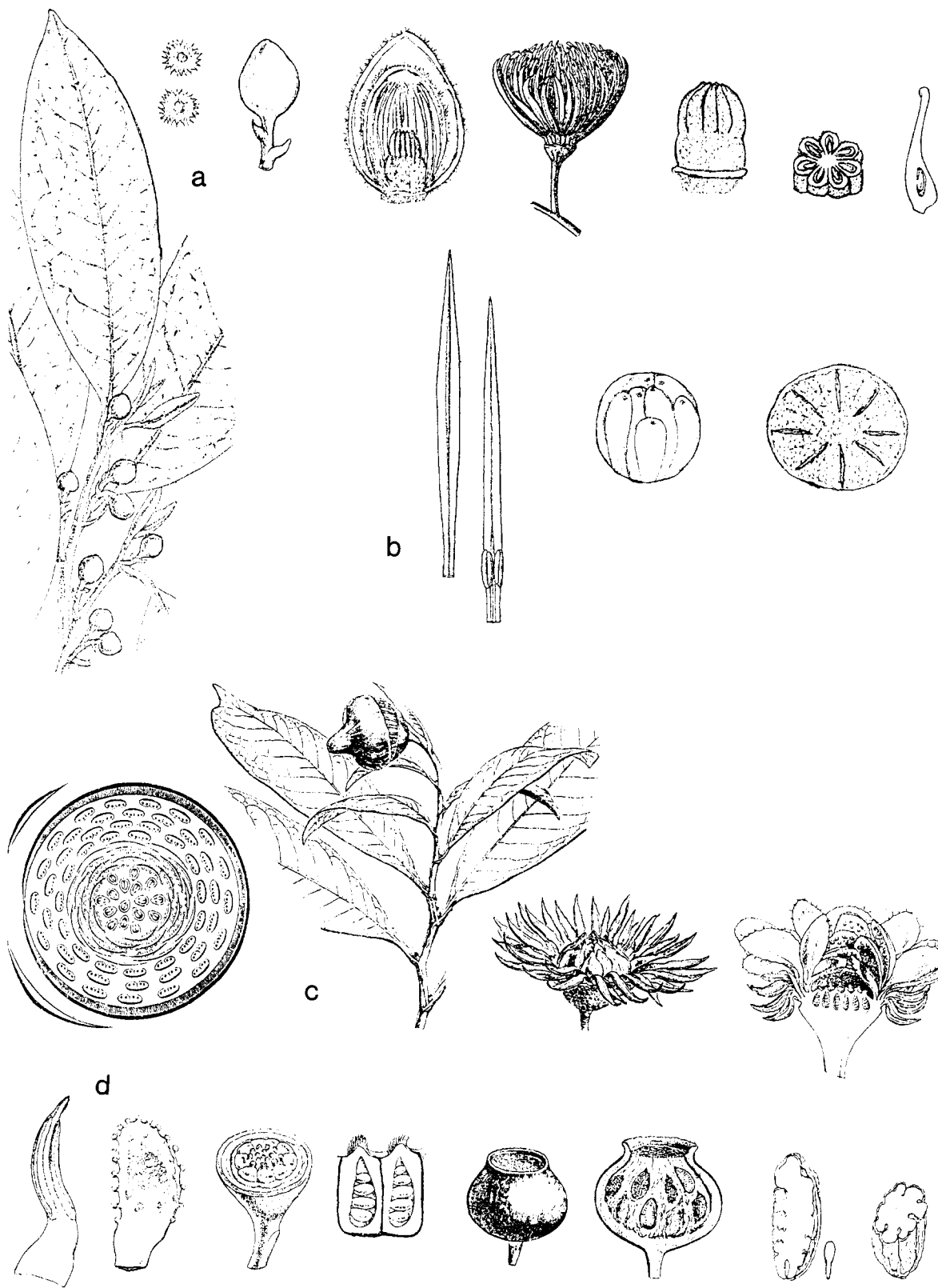
Distribution: Rain forest of northeastern Australia, New Guinea, and the Moluccas.

EUPOMATIACEAE (Figure 10c,d).—Shrubs or small trees; xylem vessel perforation plates scalariform with 20-100 bars; leaves simple, alternate, entire, exstipulate; flower solitary, terminal, bisexual, the parts perigynous; perianth (?bracts) calyptrate; stamens numerous (to ~50), spirally arranged, anthers adnate, the connective acuminate; staminodes internal to the stamens petaloid and bearing food-bodies eaten by beetles; pollen 2-3-sulcate, sometimes with an annular groove; pistils numerous (~16), contiguous but free, incompletely closed, immersed in an urceolate receptacle, the stigmas penicillate, essentially sessile; ovules several per pistil, bitegmic, crassinucellar, anatropous; fruit nutlets (achenese?) enclosed in a fleshy receptacle which is apically truncate; embryo minute, 0.1 the length of the endosperm; endosperm copious, ruminant.

Composition: 1 genus, 2 species.

Distribution: Temperate and tropical eastern Australia, New Guinea.

Myristicaceae (Figure 11a,b).—Trees; xylem vessel perforation plates scalariform, the bars few, occasionally to 20, sometimes also simple;



leaves simple, persistent, alternate, entire, often pellucid-punctate, sometimes distichous, exstipulate; inflorescences axillary or supra-axillary panicles, racemes, cymes, fascicles, or heads, the plants dioecious; flowers small, the parts hypogynous; sepals 3 (2–5), connate, colored, the calyx saucer-shaped to globose, the lobes valvate; petals 0; stamens 2–45, the filaments usually united into a column, sometimes nearly free; anthers connate or free, the connective sometimes apically produced; pollen 1-sulcate, in some cases nonaperturate(?); pistil 1, unicarpellate, the ovule 1, subbasal, bitegmic, crassinucellar, anatropous, rarely suborthotropous, the stigma sessile, apical; fruit usually a berry, usually splitting along both sutures; seed large, often with a laciniate, colored aril; embryo minute, 0.2 the length of the endosperm; cotyledons divaricate and grading into the radicle, 0.7 the length of the embryo, or united; endosperm copious, usually ruminant, oily or starchy.

Composition: ~17 genera, ~300 species.

Distribution: Tropical lowland rain forest of America, Asia, Africa, Madagascar, the East Indies, northeastern Australia.

CANELLACEAE (Figure 11*c,d*).—Trees; xylem vessel perforation plates scalariform with 10–60 bars; leaves simple, alternate, leathery, entire, glandular-punctate, exstipulate; inflorescence a terminal or axillary cyme or raceme, or the flowers solitary; flowers bisexual, small, the parts hypogynous; sepals 3–5, free, thick, imbricate; petals 4–5 (–12) free or connate, or 0, 3–5-merous, rarely spirally arranged; stamens 7–40, connate in a tube; anthers adnate, extrorse; pollen 1-sulcate; pistil 1, the carpels 2–6, the style 1 short and thick, stigmas 2–5, apical; ovary uni-

locular, the placentas parietal 2–6, the ovules 2-several, bitegmic, crassinucellar, anatropous or semi-anatropous; fruit a berry, the seeds shining; embryo linear, straight or slightly curved, 0.2–0.4 the length of the endosperm; cotyledons not broadened(?), 0.4 the length of the embryo; endosperm copious, ruminant, oily and fleshy.

Composition: 5 genera, ~16 species.

Distribution: Tropics of northern South America, the West Indies; Florida; eastern and southern Africa, Madagascar.

SCHISANDRACEAE (Figure 12*a–c*).—Climbing or trailing shrubs; xylem vessel perforation plates scalariform with 7–15 bars, sometimes also simple; leaves simple, alternate, often pellucid-punctate, entire or crenate-serrate, exstipulate; flowers small, axillary, usually solitary, the parts hypogynous, the plants monoecious or dioecious; perianth parts 9–15, spirally arranged, with gradual transition from sepals to petals; stamens 5 to ~60, partially or wholly connate into a fleshy globose mass, spirally arranged or in 1 or more whorls; anthers small, basifixed, extrorse or introrse, as long as wide, with connective separating the thecas but not apically produced, staminodes rare; pollen 3- or 6-colp(oid)ate; pistils 20–30 (12–120), spirally arranged, only partly closed, the style short, stigma decurrent ventrally; ovules 2–5, ventral, bitegmic, crassinucellar, anatropous or campylotropous; fruit berries or drupaceous; embryo minute, straight, 0.2 the length of the endosperm; cotyledons divaricate, not broadened, 0.5 the length of the embryo; endosperm copious, oily.

Composition: 2 genera, 47 species.

Distribution: Eastern temperate and tropical China to northeastern India, Malaya, the western East Indies; southeastern United States.

ILLICACEAE (Figure 12*d,e*).—Shrubs or small trees; xylem vessel perforation plates scalariform with numerous bars (to 150); leaves simple, alternate or subverticillate, entire, exstipulate; flowers solitary, axillary or supra-axillary, rarely cauliflorous, bisexual, the parts hypogynous; perianth homiochlamydeous, the parts free, 7–33, spirally arranged, the outmost small and brac-

FIGURE 10.—HIMANTANDRACEAE: *a*, *Galbulimima baccata* twigs in bud, indument scales, bud, l.s. of bud, flower, pistil, c.s. of same, l.s. of carpel; *b*, staminode, stamen, fruit, c.s. of same (after Lauterbach, Sprague). EUPOMATIACEAE: *c*, *Eupomatia bennettii* floral diagram, flowering twig, *E. laurina* flower, l.s. of same; *d*, stamen, inner staminode, carpels, l.s. of 2 carpels, fruit, l.s. of same, l.s. of seed showing the minute embryo, embryo, c.s. of seed (after Baillon, 1866–1895; R. Brown).

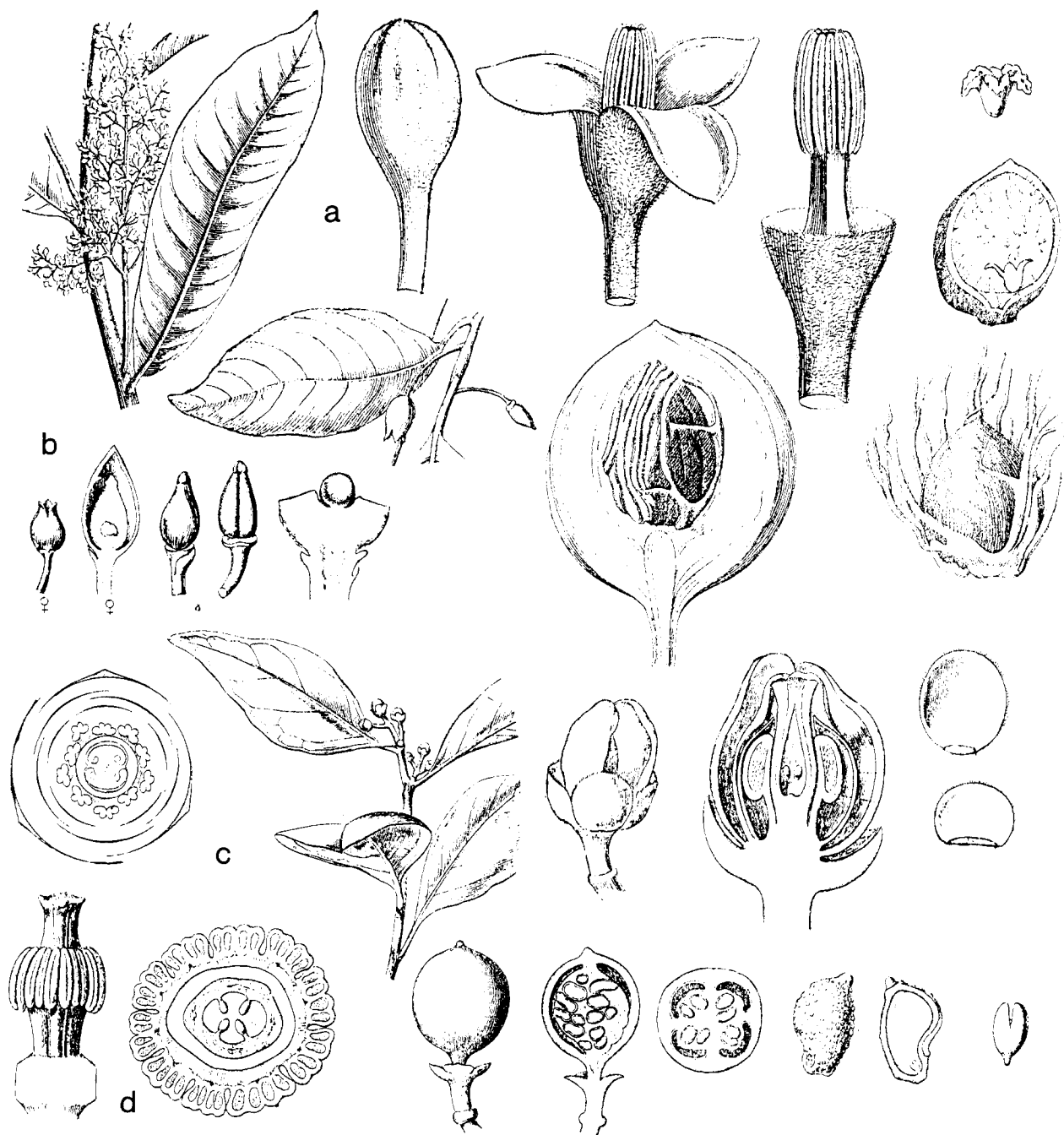


FIGURE 11.—MYRISTICACEAE: *a*, *Myristica surinamensis* ♂ inflorescence, bud, ♂ flower, ♂ flower with sepals removed, *M. fragrans* embryo and l.s. of seed; *b*, ♀ flower, l.s. of same, views of pistil, section of part of ovary with ovule, part of twig with ♀ inflorescence, l.s. of fruit, seed with aril (after Martius, 1840–1906). CANELLACEAE: *c*, *Cinnamodendron axillare* floral diagram, twig in bud, bud, l.s. of same, petal and sepal; *d*, essential organs, c.s. of same, *C. corticosum* fruit, l.s. and c.s. of same, seed, l.s. of same showing the minute embryo, embryo (after Martius, 1840–1906).



FIGURE 12.—SCHISANDRACEAE: *a*, *Schisandra coccinea* ♂ flowering twig, androecium and ♂ floral diagram, l.s. of ♀ flower, l.s. of pistil, gynoecium, seed and l.s. of same showing the minute embryo, fruitlets; *b*, *Kadsura japonica* ♂ flower, l.s. of same, androecium, stamen; *c*, calyx, cluster of fruitlets, a fruitlet, l.s. of same (after Baillon, 1866-1895; Le Maout and Decaisne, 1873; Lindley, 1853). ILLICIACEAE: *d*, *Illicium micranthum* flowering twigs, *I. anisatum* flower, *I. micranthum* flower, inner petal and 3 stamens, stamen; *e*, *I. anisatum* gynoecium, dehiscent fruit, seed, l.s. of same showing the minute embryo (after Martius, 1840-1906; Dunn).

teole-like, inner ones becoming larger and ligulate or suborbicular, the innermost often reduced; stamens usually numerous, 4–50; anthers oblong or as long as wide, introrse, basifixed or adnate, the thecas sometimes separate, the connective sometimes glandular, but not or only slightly apically produced; pollen 3-colp(oid)ate; pistils 5–15 (–21) in 1 whorl, compressed laterally, narrowed into a style, the stigma decurrent ventrally, the ovule ventral-subbasal, bitegmic, crassinucellar, anatropous; fruit a follicetum, seeds glossy, the embryo minute, 0.06–0.1 the length of the endosperm; cotyledons hardly differentiated to 0.5 the length of the embryo; endosperm copious, fleshy.

Composition: 1 genus, ~40 species.

Distribution: Japan, Korea, eastern China to Malaya, Borneo, and the Philippines; southeastern United States, eastern Mexico, West Indies.

AMBORELLACEAE (Figure 13*c,d*).—Shrubs; xylem vesselless; leaves alternate, entire, or repand and obscurely toothed, finally distichous, exstipulate; inflorescences axillary ♂ panicle, ♀ cyme or fascicle, the flowers small, unisexual, or sometimes ♀ flowers with 2–3 stamens, the parts hypogynous to weakly perigynous, perianth homiochlamydeous, the parts 8, spirally arranged, weakly connate basally; stamens about 18, in several whorls, broad, the outer ones adnate to the perianth at its base; anthers extrorse, the thecas dehiscing longitudinally, pollen nonaperturate; pistils 5–6, incompletely closed, in 1 whorl, the stigmas decurrent ventrally, the ovule 1, bitegmic, crassinucellar, orthotropous(?); fruitlets compressed drupelets, stipitate; seed small, the embryo minute, not differentiated, 0.1 the length of the endosperm; endosperm copious.

Composition: 1 genus, 1 species.

Distribution: New Caledonia.

TRIMENIACEAE (Figure 13*a,b*).—Trees, shrubs, or climbers; xylem vessel perforation plates scalariform with more than 20 bars; leaves simple, alternate or opposite, entire or crenate, coriaceous, sometimes glandular punctate, exstipulate; inflorescences axillary or terminal racemes or panicles; flowers bisexual or the plants

sometimes dioecious, small, numerous, the parts hypogynous; sepals 6 or 4, or an indefinite number of bracteoles and sepals; petals 0; stamens 6–22 in 1–3 whorls, hardly differentiated into anther and filament, or anthers oblong, basifixed, as long as the filament, extrorse, the connective apically produced, staminodes sometimes present; pollen 8–12 pored, or with 2 irregular, unthickened areas; pistil 1 (–2); stigma sessile, capitate, papillose; fruit a berry or drupelet; seeds compressed, the embryo small, the endosperm copious, gelatinous.

Composition: 2 genera, 5 species.

Distribution: New Guinea, New Caledonia, Fiji, and eastern Australia.

MONIMIACEAE (Figure 14*a–c*).—Mostly shrubs, rarely trees or climbers, with a characteristic aromatic fragrance; xylem vessel perforation plates usually predominantly scalariform with more than 20 bars (to 100 in *Atherosperma*), sometimes predominately simple, rarely only simple; leaves simple, opposite, rarely alternate, entire or serrate, coriaceous, pellucid-punctate, exstipulate; inflorescences axillary, rarely terminal, cyme or raceme, or the flowers rarely solitary; flowers bisexual or the plants dioecious or monoecious; perianth parts in 2 or more series or acyclic, homiochlamydeous or the outer sepaloid and the inner petaloid, 4–20 or rarely 0, hypogynous to perigynous, the calyx oblique like *Aristolochia* in *Glossocalyx*; stamens numerous, to ~150, or few, rarely 1, in 1–2 series, usually free, rarely connate (*Tetrasynandra*), the filaments very short, often flattened, sometimes with a gland on each side at the base; anthers adnate or basifixed, dehiscing by longitudinal slits or by valves from the base upwards, introrse or extrorse, the connective sometimes apically produced, staminodes sometimes present; pollen nonaperturate or 2(–3)-sulculate; disk adnate to the concave receptacle; pistils numerous, to ~100, several, or rarely 1, rarely connate or adnate to the receptacle, the style elongated or short, rarely subbasal, the stigma apical; ovule 1, apical, basal or marginal, 1–2-tegmic, crassinucellar, anatropous (orthotropous in *Daphnan-*

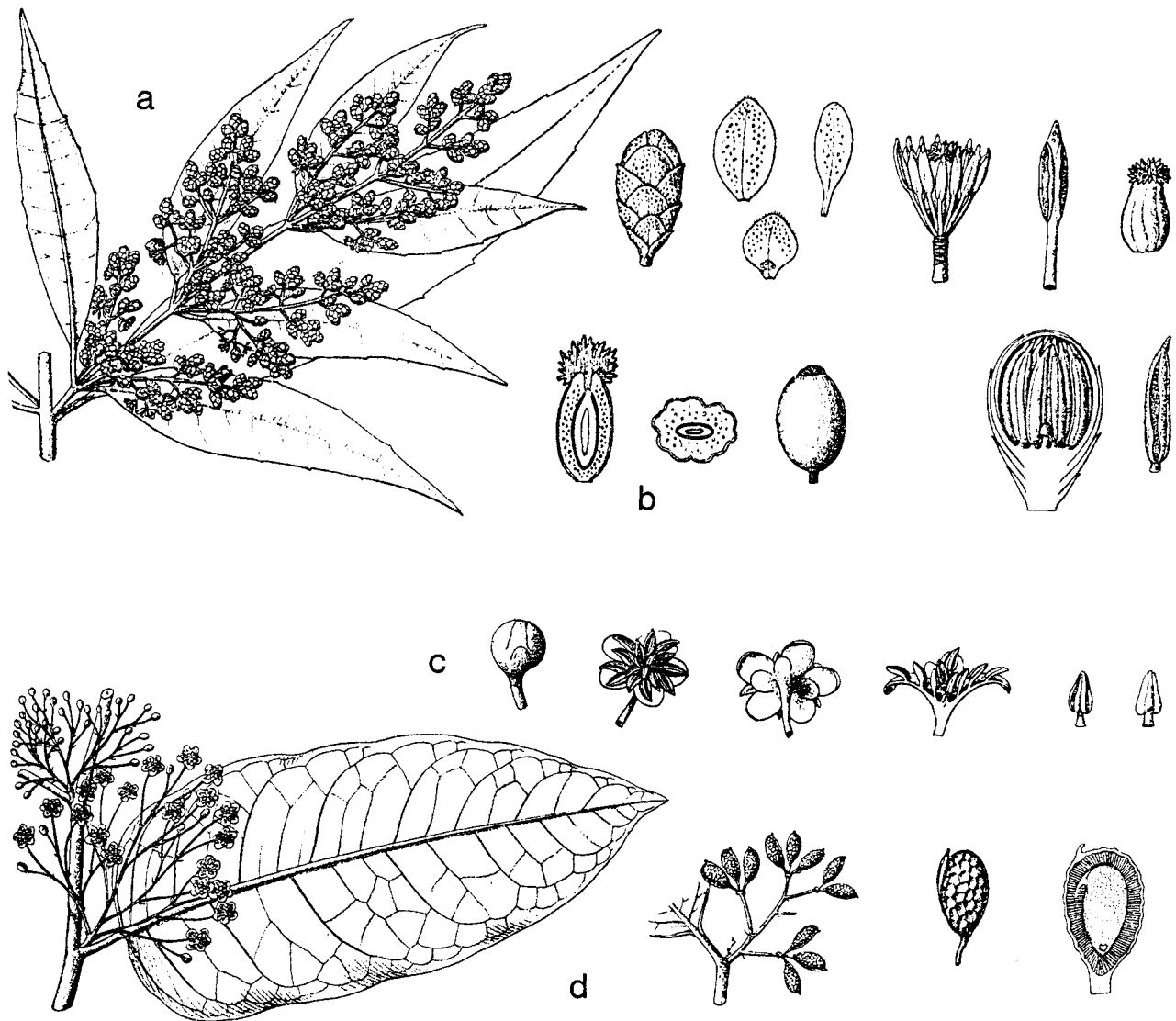


FIGURE 13.—TRIMENIACEAE: *a*, *Trimenia papuana* flowering twig, flower bud, outer, middle and inner tepals, flower with tepals removed, stamen, pistil; *b*, l.s. and c.s. of pistil, fruit, *T. weinmanniifolia* l.s. of bud (δ ?), stamen (after Gilg and Schlechter, Perkins and Gilg). AMBORELLACEAE: *c*, *Amborella trichopoda* δ bud, δ flower from above and below, l.s. of δ flower, views of stamen; *d*, part of twig with δ inflorescence, infructescence, fruitlet, l.s. of same showing the minute embryo (after Perkins and Gilg).

dra?); fruitlets drupes or achenes enclosed in or borne on a fleshy receptacle; seed may have a very fleshy testa (*Baldoa*), an aril rarely present (*Siparuna*); embryo minute, straight, 0.2–0.5 the length of the endosperm; cotyledons erect or divaricate, thin, 1–4 times the width of the radi-

cle, 0.3–0.75 the length of the embryo; endosperm copious, oily.

Composition: ~30 genera, ~450 species.

Distribution: Mainly tropics and subtropics of the Southern Hemisphere; tropical to south temperate America; Sri Lanka, Malaya, and the East

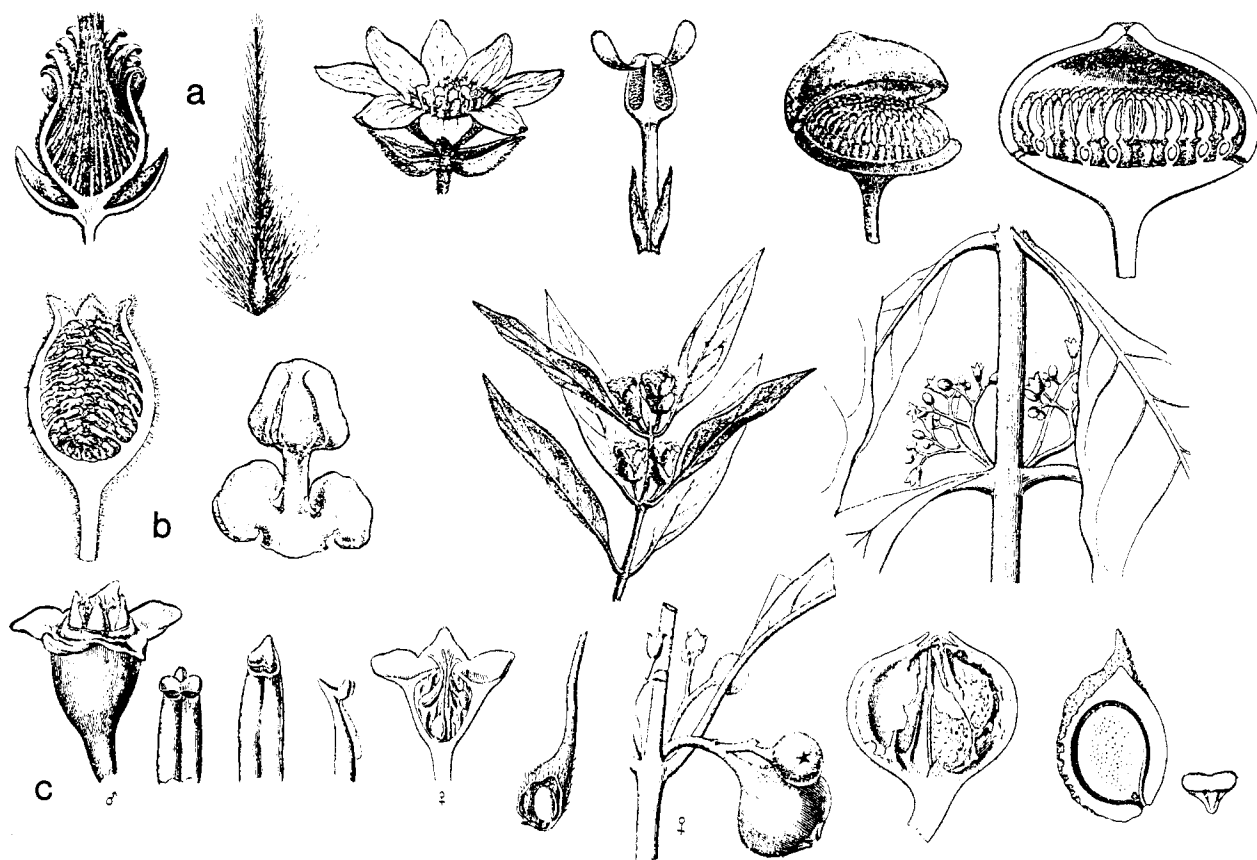


FIGURE 14.—MONIMIACEAE: *a*, *Atherosperma moschata* l.s. of ♀ flower, a pistil, ♂ flower, dehiscent stamen, *Mollinedia sancta* ♀ flower, l.s. of same; *b*, *Monimia citrina* l.s. of ♂ flower, stamen, *Atherosperma moschata* flowering twig, *Siparuna apiosyce* part of ♂ flowering twig; *c*, ♂ flower, views of open, closed and open anthers, l.s. of ♀ flower, pistil with ovary opened, part of twig with ♀ flowers and fruit, l.s. of fruit, *S. oligandra* l.s. of drupelet showing the minute embryo, embryo enlarged (after Baillon, 1866–1895; Martius, 1840–1906).

Indies; eastern Australia, New Zealand; relatively poorly represented in tropical rain forest of western Africa and in eastern Africa and Madagascar.

IDIOSPERMACEAE (Figure 15*a,b*).—Trees; xylem vessel perforation plates scalariform; leaves simple, entire, opposite, coriaceous, exstipulate; inflorescence axillary, of 1 (–3) flowers; flowers bisexual, the perianth parts 30–40, perigynous, spirally arranged, petaloid, the receptacle urceolate; stamens 13–15 the inner ones staminodal, the filaments very short; anthers extrorse, laminar; pollen dicolpate; pistil 1 (–2), unicarpellate, at the base of the receptacle, the stigma broad, subsessile, fleshy, papillose; ovules 1–2, basal; fruits 1–2-seeded nutlets enclosed within the

somewhat fleshy receptacle; embryo large, the cotyledons 3–4, massive, peltate, the radicle short, invested or shortly exserted, the plumule well developed; endosperm 0.

Composition: 1 genus, 1 species.

Distribution: Rain forest of northern Queensland, Australia.

CALYCANTHACEAE (Figure 15*c,d*).—Shrubs; xylem vessel diameter very small, the perforation plates simple; leaves simple, entire, opposite, exstipulate; flowers bisexual, solitary, axillary or terminal on axillary shoots, fragrant, the parts perigynous, the receptacle urceolate; perianth homoioclamydeous to incompletely heteroclamydeous, the parts numerous, petaloid, spi-

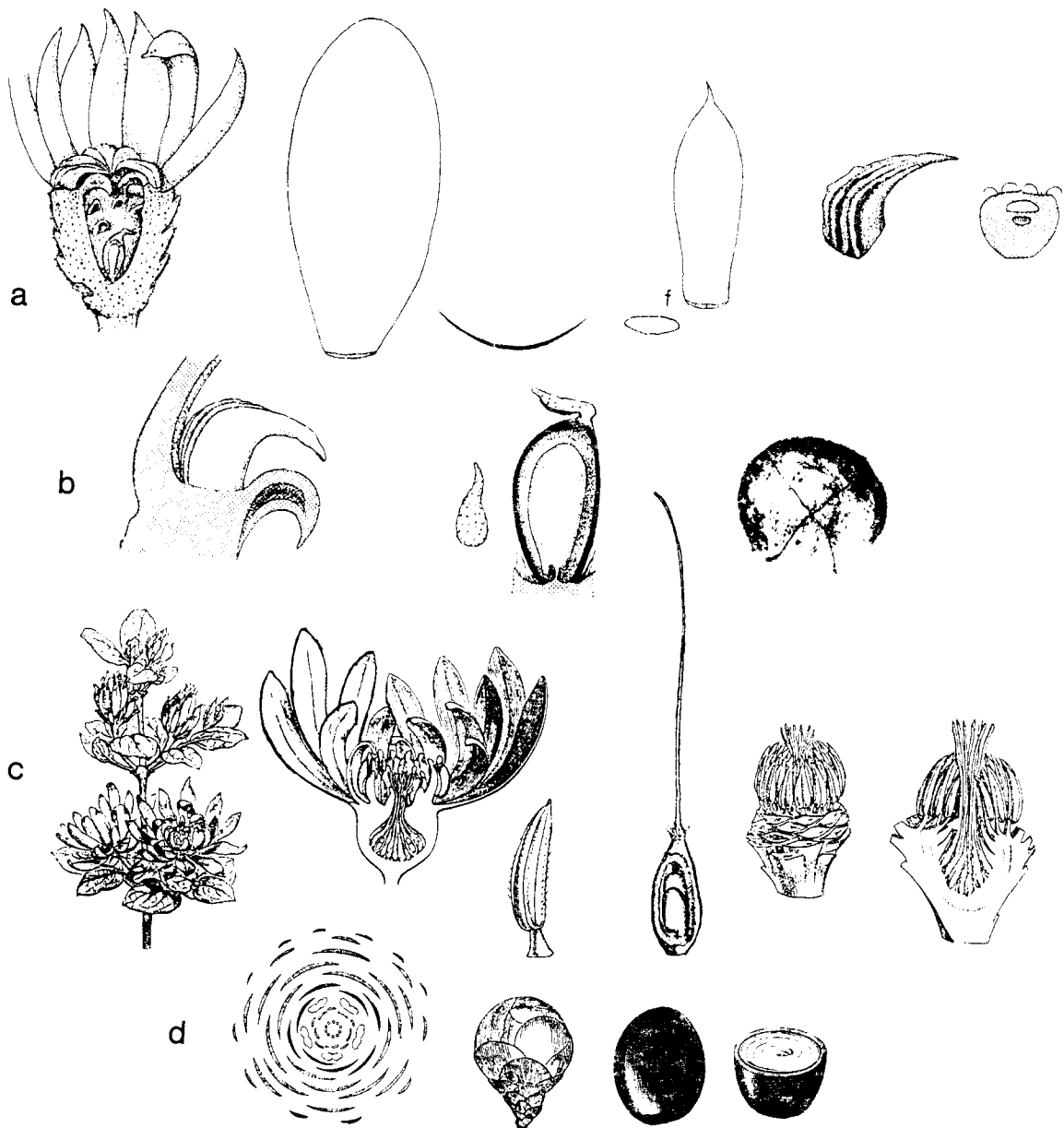


FIGURE 15.—IDIOSPERMACEAE: *a*, *Idiospermum australiense* l.s. of flower, the outer tepals fallen, outer and inner tepals and c.s. of same, stamen and c.s. of same; *b*, l.s. of tepal, stamen and pistil, embryo showing 4 massive cotyledons (after Blake). CALYCANTHACEAE: *c*, *Calycanthus floridus* flowering twig, l.s. of flower, stamen, l.s. of ovary, *C. occidentalis* flower with perianth removed, l.s. of same; *d*, *Chimonanthus praecox* floral diagram, bud, seed, c.s. of same showing the convolute embryo (after Baillon, 1866–1895; Le Maout and Decaisne, 1873).

rally arranged with gradual transition in size; stamens 5–30, the inner ones staminodal (7–17) with fleshy apex eaten by beetles, the filaments very short; anthers large, adnate, extrorse, the

connective apically produced; pollen 2 (–3?)–sulculate; pistils about 3–20, at the base of the receptacle, the styles long, filiform, the stigmas obtuse, apical; ovules 1–2, ventral, bitegmic, sub-

crassinucellar, anatropous; fruitlets achenes enclosed in the enlarged, slightly fleshy receptacle; embryo large, the cotyledons foliose, convolute, much broader than the radicle, 0.7 the length of the embryo; endosperm 0 or very scanty.

Composition: 2 genera, 6 species.

Distribution: Temperate China; southeastern and western United States.

LAURALES

Trees and shrubs, rarely twining parasitic herbs; xylem vessel perforation plates scalariform or simple; leaves usually alternate, entire or lobed, simple or rarely digitately compound, exstipulate; flowers small, bisexual or unisexual; perianth usually whorled, rarely spirally arranged, frequently 3-merous, usually perigynous, more rarely hypogynous or epigynous; stamens 3–12 (–36) in one or more whorls, the filaments with a gland on each side at the base, the anthers opening by valves; pollen nonaperturate; pistil 1, pseudomonomerous, the stigma usually apical or subapical; ovules 1 per ovary or locule; fruit a berry, drupe or nutlet, rarely a samara; embryo medium-sized to large; endosperm usually absent rarely copious.

Distribution: Centered in southeastern Asia and tropical America, in lowland and montane rain forest.

Chemistry: Laurales are rich in characteristic aromatic oils, such as monoterpenes and sesquiterpenes. They are cyanogenic.

GOMORTEGACEAE (Figure 16*a,b*).—Tree; xylem vessel perforation plates scalariform, usually with numerous bars; leaves simple, opposite, entire, coriaceous, exstipulate; inflorescences axillary and terminal racemes or panicles; flowers small, bisexual, the parts epigynous; perianth homiochlamydeous with 6–10 spirally arranged parts; stamens 9 (2–11), the filaments short to somewhat elongated, the inner ones with a gland on each side, sometimes 3 staminodes present; anthers introrse, opening by valves; pollen nonaperturate; pistil 1, the carpels 2–3, the style 1 with 2–3 stigmatic lobes; ovary 2–3-locular, the

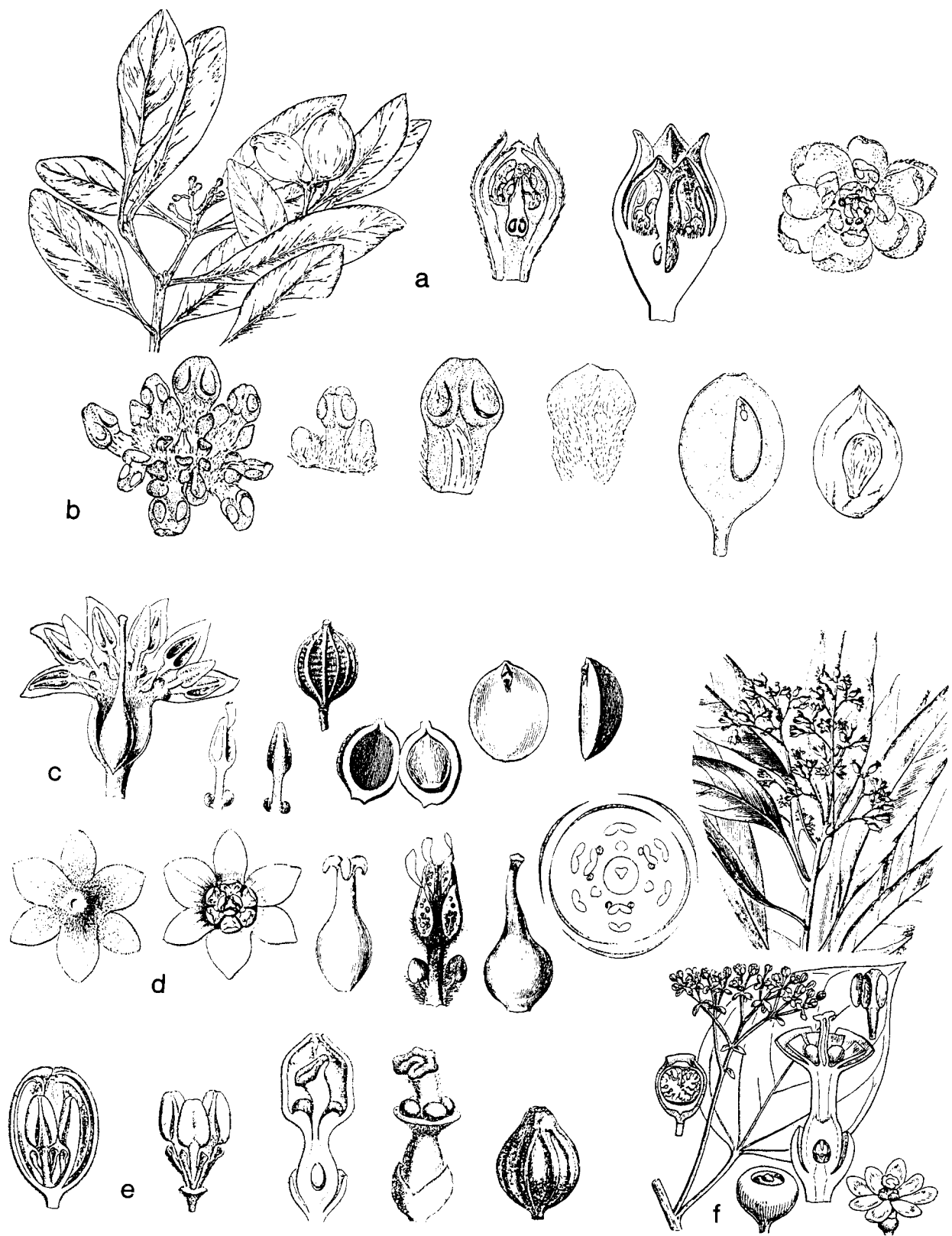
ovules 1 per locule, axile-subapical; fruit a drupe; embryo medium-sized, 0.2 the length of the endosperm; cotyledons 3 times the width of the radicle, 0.7 the length of the embryo; endosperm copious, oily.

Composition: 1 genus, 1 species.

Distribution: Central Chile.

LAURACEAE (Figure 16*c,d*).—Trees or shrubs, very rarely twining parasitic herbs; xylem vessel perforation plates simple, occasionally a few sporadic scalariform; leaves simple, alternate, rarely opposite or subopposite, evergreen or deciduous, usually entire, rarely lobed, exstipulate; inflorescences axillary, rarely terminal, cymes or racemes, umbelliform or paniculate, rarely heads; flowers small, usually trimerous, rarely dimerous, greenish or yellowish, bisexual or the plants sometimes polygamous or dioecious; perianth in 2 or 3 trimerous (dimerous) whorls or very rarely absent, the parts hypogynous or perigynous, sometimes basally connate; stamens 3–12 (–36) in 1–4 whorls, filaments often with a gland on each side of the base, staminodes commonly present; anthers basifixed, dehiscing by valves from the base upward, very rarely by minute pores (*Hexapora*); pollen nonaperturate; annular disk in *Synandrodaphne* (*Ocotea*); pistil 1, unicarpellate (derived from 3 carpels), the ovary superior, very rarely inferior (*Hypodaphnis*), the style elongated or absent, the stigma 1 (2–3)

FIGURE 16.—GOMORTEGACEAE: *a*, *Gomortega keule* twigs with inflorescence and infructescence, l.s. of bud, l.s. of flower, flower; *b*, essential organs, stamen and staminodes, views of stamen, l.s. of fruit showing the minute embryo, l.s. of seed (after Baillon, 1866–1895; Muñoz Pizarro, 1959). LAURACEAE: *c*, *Cryptocarya moschata* flower laid open, views of stamen, fruit, l.s. of same showing seed, views of ½ the embryo; *d*, *Nectandra gardneri* calyx from below, flower, pistil, *Persea erythropus* dehiscent stamen, pistil, floral diagram, *Cryptocarya moschata* part of flowering twig (after Martius). HERNANDIACEAE: *e*, *Hernandia sonora* l.s. of ♂ flower, ♂ flower without the perianth, l.s. of ♀ flower, ♀ flower without the perianth, fruit; *f*, *H. jamaicensis* fruit and l.s. of same, *H. catalpifolia* inflorescence in axil of leaf, l.s. of ♀ flower, the perianth partly removed, stamen with 1 anther sac dehiscent, ♀ flower (after Baillon, 1866–1895; Martius, 1840–1906; Fawcett and Rendle).



apical, ovule 1 subapical, bitegmic, crassinucellar, anatropous; fruit a berry or drupe, sometimes partly or entirely enclosed by the enlarged, cupular receptacle; embryo large, straight, the cotyledons thick, plano-convex, 9 times the width of the radicle, 0.8–0.9 the length of the embryo, radicle invested, plumule sometimes evident; endosperm 0.

Composition: 32 genera, ~2250 species.

Distribution: Centered in southeastern Asia, the East Indies, and tropical America, in lowland and montane rain forest; less commonly in Africa, the Mediterranean region, Australia, New Zealand, and temperate North America.

HERNANDIACEAE (Figure 16*e,f*).—Trees or shrubs, sometimes scandent; xylem vessel perforation plates predominantly simple, occasionally scalariform; leaves alternate, entire or lobed, simple or digitately compound, exstipulate; inflorescence axillary cyme, thyrses or corymbs; flowers small, bisexual, or sometimes the plants monoecious, polygamous, or dioecious, the parts epigynous; perianth parts 3–10 in 1–2 whorls; stamens 3–6 in 1 whorl, sometimes 1–2 whorls of staminodes present, the filaments sometimes with a gland or two at their base; anthers basifixed, dehiscent by valves; pollen nonaperturate; pistil 1, unicarpellate (derived from 3 carpels), the style elongate, stigma enlarged, subapical, the ovary inferior, ovule 1, subapical, bitegmic, crassinucellar, anatropous; fruit a nutlet enclosed by the enlarged receptacle, or a samara; embryo large, the cotyledons large, planoconvex or flat and spirally twisted around the radicle; endosperm 0.

Composition: 4 genera, ~65 species.

Distribution: Most commonly along seacoasts; tropical Central America, Venezuela, and Colombia, Africa, southeastern Asia, the East Indies, northeastern Australia.

ARISTOLOCHIALES

The order is monotypic.

Chemistry: Aromatic oils and aporphines are common. Chemical evidence does not strongly favor a relation with Nepenthaceae.

ARISTOLOCHIACEAE (Figure 17*a–c*).—Shrubs and herbs, usually climbing, the tissues containing oil cells with a characteristic spicy fragrance similar to that of members of the Magnoliales and Laurales; xylem vessel perforation plates simple; leaves alternate, simple, mostly entire, exstipulate; inflorescence axillary, terminal or cauliflorous, the flowers solitary or in racemes; flowers bisexual, often fetid, the parts perigynous or epigynous; sepals often connate in a petaloid symmetrical or asymmetrical tube sometimes 3-lobed of the apex; petals usually 0, sometimes 3; stamens (4–) 6–40 in 1 or 2 whorls, the filaments short, free or more often connate in a tube adnate to the style; anthers free or connate and adnate to the style; pollen nonaperturate or 1-sulcate; pistils 6, or 1 and then the carpels 6 (3–5), the styles free or connate, short, the stigmatic lobes 6 (3–25); ovary inferior or semi-inferior, the locules 6 (3–5) sometimes incomplete, the ovules numerous, axile, bitegmic, crassinucellar, anatropous; fruit a capsule or follicle, dehiscent from the base upward or along the ventral sutures, or rarely an indehiscent, ribbed nutlet; seeds usually numerous; embryo minute, linear, 0.05–0.2 the length of the endosperm, the cotyledons 0.4 the length of the embryo and as wide as the radicle; endosperm copious, fleshy or subhorny.

Composition: 7 genera, ~500 species.

Distribution: Mainly tropical, but extending into temperate regions; America, Eurasia, the East Indies, Africa.

RANUNCULALES

Usually shrubs and herbs, sometimes climbing; xylem vessel perforation plates usually simple, occasionally scalariform with few bars; leaves alternate, frequently compound, lobed, dissected or dentate, exstipulate; flowers large to small, bisexual or unisexual, the parts hypogynous; perianth 3–5-merous in whorls, or indefinite and spirally arranged; stamens numerous and spirally arranged, less frequently 6 and whorled; anthers basifixed, the connective sometimes apically produced; pollen usually 3-colpate or -colporate,

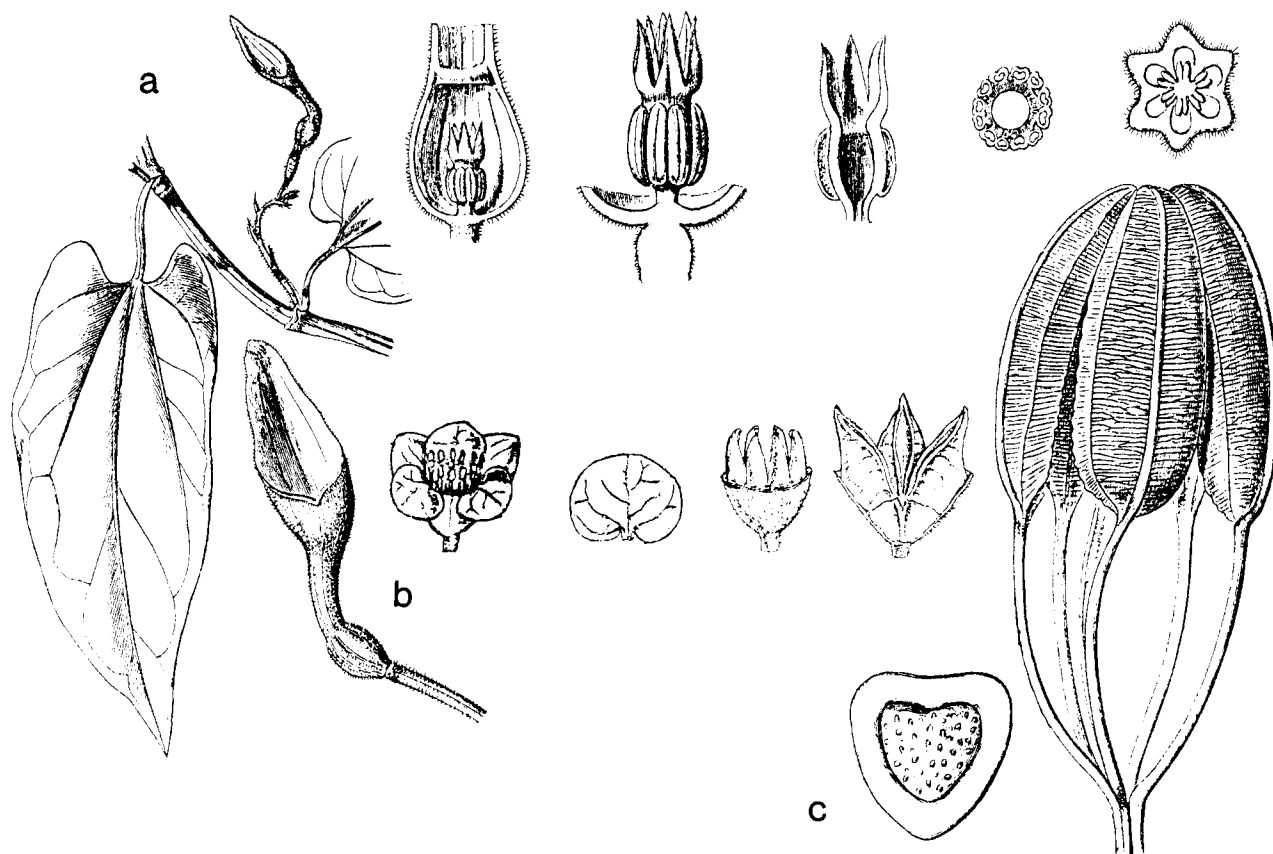


FIGURE 17.—ARISTOLOCHIACEAE: *a*, *Aristolochia acutifolia* flowering twig, l.s. of base of perianth showing stigmas and androecium, stigmas and androecium enlarged, l.s. of same, c.s. of androecium, c.s. of ovary; *b*, flower, *Saruma henryi* flower, petal, calyx tube and carpels, l.s. of fruit; *c*, *Aristolochia cymbifera* seed, dehiscent fruit (after Martius, 1840–1906; Oliver).

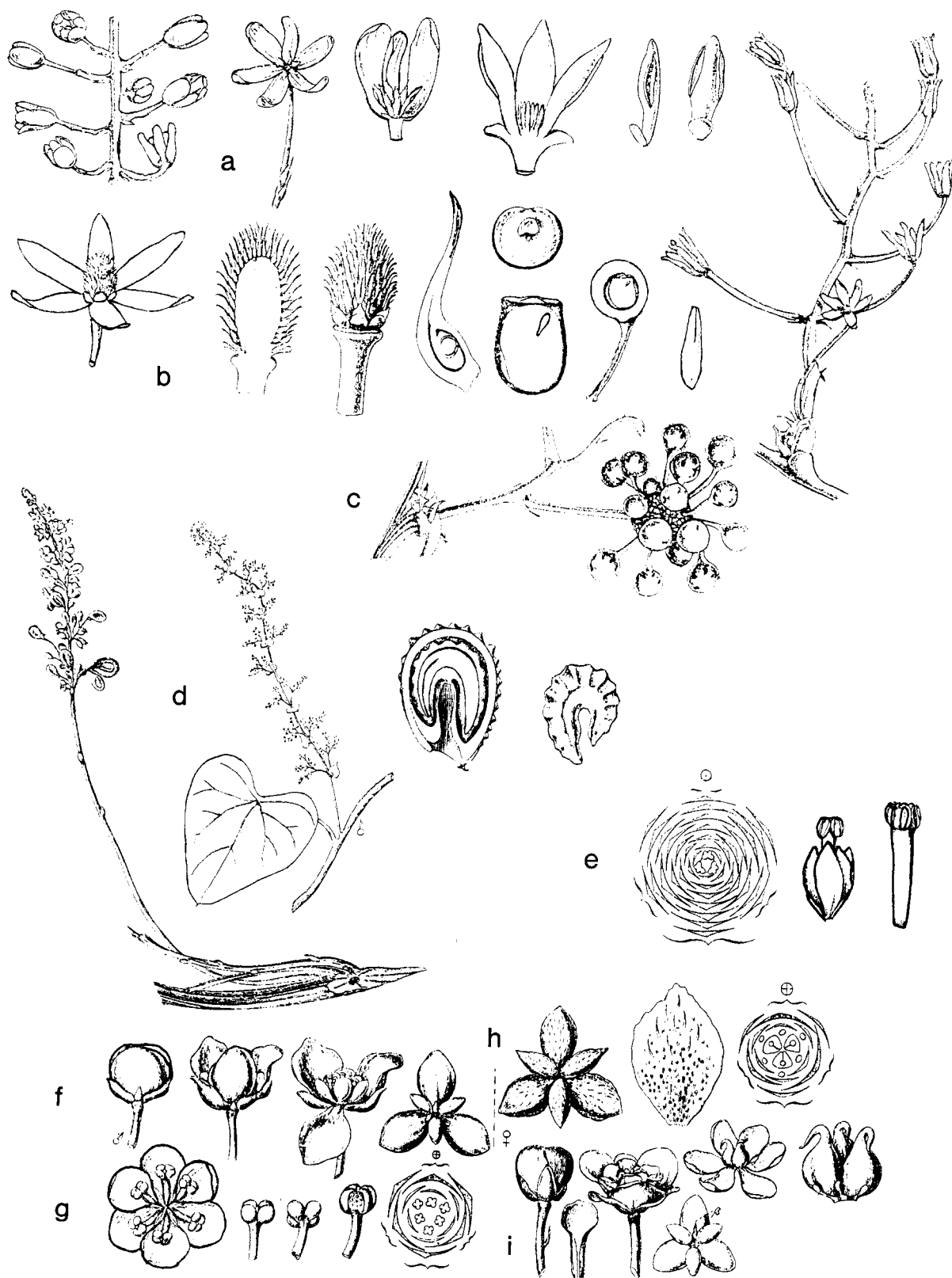
more rarely multiporate or nonaperturate; pistils usually indefinite in number, often numerous but sometimes only 1 and unicarpellate, spirally arranged or whorled, the style elongate or short, stigma decurrent ventrally or apical, the ovules 1–many; fruits achenes, drupelets, berries, rarely follicles or a capsule; embryo usually small and linear; endosperm usually copious, rarely scanty or absent.

Distribution: Ranunculaceae cosmopolitan, centered in temperate and cold regions, the other families are centered in temperate Asia except Menispermaceae, which are most abundant in tropical rain forest.

Chemistry: Aromatic oils are absent. They have very few terpenoid substances; Magnoliales have many. Aporphines are common. The alka-

loids suggest relationship between Ranunculales and Magnoliales; several groups of alkaloids occur in both. The Ranunculales, however, have some groups that have not been detected in the Magnoliales. The alkaloids also suggest relation with Aristolochiales, Piperales, Papaverales, and Rurales. Morphine occurs in Menispermaceae and Lauraceae as well as Papaveraceae. *Nandina* is the only genus outside the Papaveraceae known with certainty to have the alkaloid protopine. In other respects it seems to fit well in the Berberidaceae. *Nandina* and *Thalictrum* have p-hydroxy-nandilonitril glucoside. Ranunculales and Magnoliales have phenolic esters and ethers, the latter order being richer than the former. Laticifers occur in the fruit of *Decaisnea*.

MENISPERMACEAE (Figure 18*d-i*).—Usually



lianas, rarely small trees or herbs; xylem vessel perforation plates simple; leaves alternate, usually simple, rarely trifoliolate, sometimes palmately lobed, not glandular, exstipulate; inflorescences axillary or cauliflorous cymes, thyrses, raceme, fascicle, or rarely the flowers solitary; plants dioecious, rarely monoecious (*Albertisia*), the flowers small, usually trimerous, the parts hypogynous; perianth sometimes homoiochlamydeous; sepals free 6 (1–12) in 1–4 whorls, or sometimes spirally arranged, increasing in size from the outside inward; petals free 6 (0–9), often in 2 whorls, usually smaller than the sepals, minute, rarely connate; stamens small, 6 or 3 (2–24) opposite the petals when 6 or 3, the filaments sometimes connate; anthers often 4-lobed, small, as long as wide, basifixed, sometimes connate, the connective not apically produced; pollen 3-colporate, occasionally (2–)3-colpate, 4–6-rug(oro)ate, or nonaperturate; pistils 3 or 6 (1–32) in one or more whorls, the style mostly short, stigma apical; ovules 2 or 1, ventral, 1–2-tegmatic, crassinucellar, anatropous, semi-anatropous, campylotropous or amphitropous; fruit drupelets, the seed often hippocrepiform; embryo linear or sometimes spatulate, arcuate, rarely spirally contorted (*Spirospermum*), as long as the endosperm; cotyledons semi-terete or flat, 0.4–

0.97 the length of the embryo; endosperm moderate, scanty or absent, fleshy.

Composition: 65 genera, ~375 species.

Distribution: Centered in tropical rain forest, few temperate; eastern and southern United States to subtropical South America; tropical and south temperate Africa, Madagascar; Japan to India, the East Indies, northern and eastern Australia.

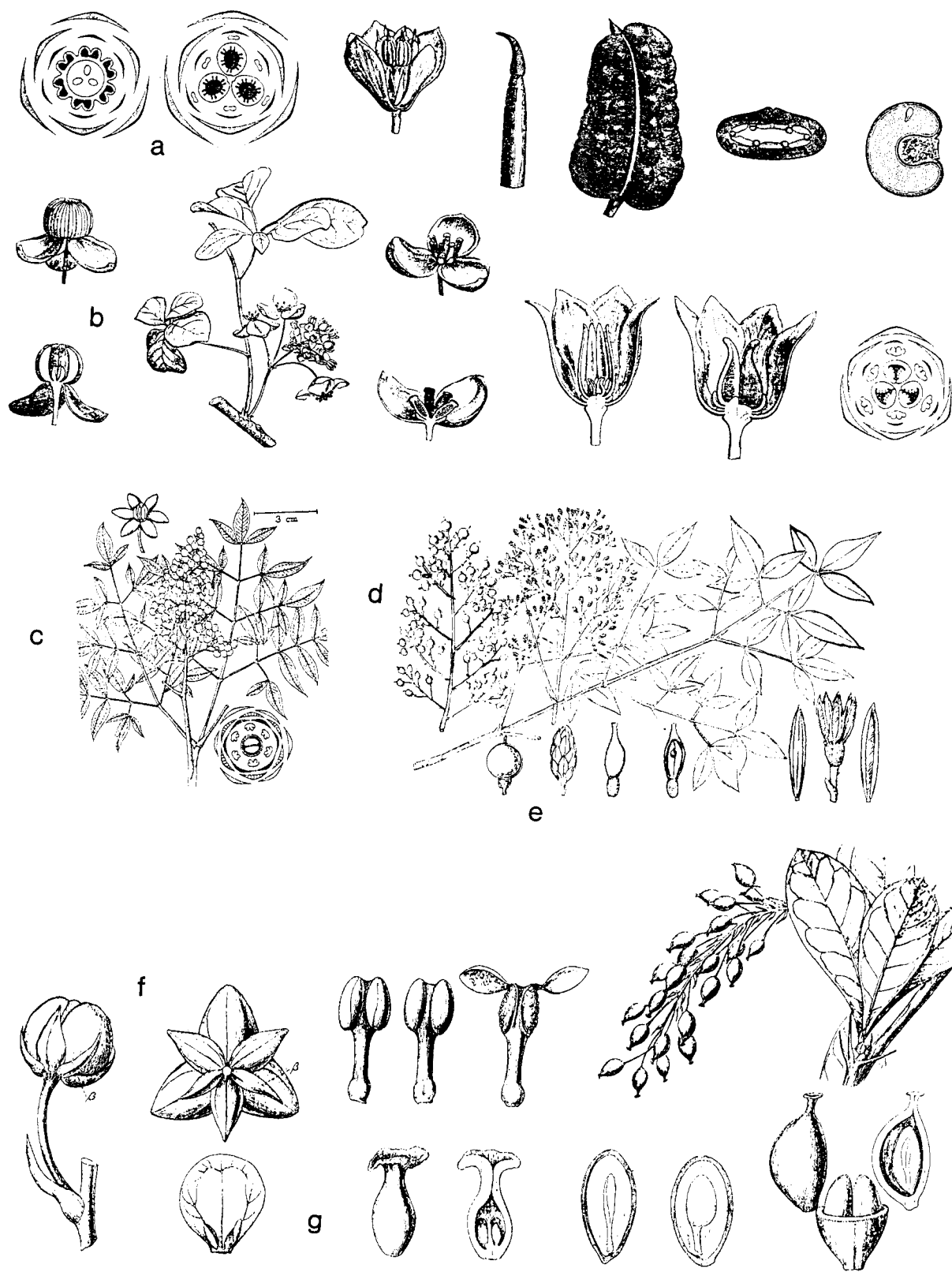
SARGENTODOXACEAE (Figure 18*a–c*).—Lianas; xylem fibers primitive; leaves alternate mostly trifoliolate, sometimes 3-lobed or entire, deciduous, exstipulate; inflorescence axillary racemes; plants dioecious, the flowers small, the parts hypogynous; sepals 6, in 2 whorls; petals 6, squamiform, glandular; stamens 6, in 2 whorls opposite the petals, the filaments short, free; anthers oblong, the connective shortly apically produced; pollen (2–)3-colporoidate; ♀ torus elongate; pistils more than 35, spirally arranged, ovule 1; fruitlets stipitate berries; embryo minute, 0.3 the length of the endosperm, subcylindrical, the cotyledons not broadened, 0.5 the length of the embryo, the radicle slightly thicker than the cotyledons; endosperm copious, fleshy, oily and starchy.

Composition: 1 genus, 1 species.

Distribution: China and Indochina.

LARDIZABALACEAE (Figure 19*a,b*).—Lianas, rarely erect shrubs; xylem vessel perforation plates simple, occasionally a few scalariform, or exclusively scalariform (*Decaisnea*), with few bars; leaves alternate, usually digitately compound, rarely 2–3-ternate or pinnately compound, exstipulate; inflorescence axillary racemes or the flowers solitary; flowers small to moderate-sized, the parts hypogynous; plants polygamous, monoecious or dioecious, the flowers of each sex with rudiments of the other sex; perianth homoiochlamydeous; sepals 3 or 6, petaloid; petals 6 or 0, smaller than the sepals, sometimes 2 whorls of 3 honey-scales between the perianth and stamens; stamens 6, the filaments short, free or connate in a tube or column; anthers basifixed, extrorse, free or connate, oblong, the connective sometimes apically produced; pollen as a rule 3-colp(oro)idate; pistils 3 or 6 (–15), in 1–5

FIGURE 18.—**SARGENTODOXACEAE:** *a*, *Sargentodoxa cuneata* part of ♂ inflorescence, ♂ flower, same with part of calyx removed, l.s. of ♂ flower with sepals removed (2 of the glandlike petals, 3 stamens and the pistillodes are visible), views of a stamen with glandlike petal at its base; *b*, ♀ flower, l.s. of same with perianth removed, ♀ flower with perianth removed, l.s. of a pistil, top-view of a seedlet and same in l.s. showing the minute embryo, l.s. of a fruitlet, embryo, part of ♀ inflorescence; *c*, part of an infructescence showing the fruitlets from 1 gynoeceum (after Stapf). **MENISPERMACEAE:** *d*, *Cissampelos fasciculata* ♀ inflorescence, *C. tamoides* ♂ inflorescence, *C. fasciculata* l.s. of fruit showing large curved embryo, seed; *e*, *Sciadotaenia microphyllum* diagram of ♂ flower, corolla and androeceum, androeceum; *f*, *Hyperbaena domingensis* ♂ bud, flower at anthesis, flower with a perianth segment depressed, flower from below; *g*, corolla and stamens from above, views of stamen, floral diagram; *h*, ♀ calyx from below, sepal, floral diagram; *i*, bud, petal, flower at anthesis, calyx and bracteole from below, corolla and pistils, pistils and staminodes (after Martius, 1840–1906).



whorls, the stigma sessile, apical; ovules parietal or ventral, numerous in 2 or more ranks, or solitary, bitegmic, crassinucellar, anatropous, campylotropous or orthotropous; fruitlets berries or fleshy follicles; embryo small, linear, straight, 0.1–0.3 the length of the endosperm, the cotyledons thin, 0.3 the length of the embryo; endosperm copious, fleshy.

Composition: 8 genera, 35 species.

Distribution: Japan, Korea to the Himalayas, to southeastern China, Indochina, Taiwan; central Chile.

NANDINACEAE (Figure 19*c–e*).—Shrub; xylem vessel perforation plates simple; leaves alternate, 2–3 times pinnately compound, exstipulate; inflorescence a terminal panicle; flowers small, bisexual, the parts hypogynous; sepals numerous, spirally arranged, gradually larger from the outer to the innermost; petals 6 slightly larger than the inner sepals, honey-scales 6; stamens 6 in 1 whorl opposite the petals; anthers elliptic, subsessile, introrse, dehiscing longitudinally, the connective slightly apically produced; pollen foss-aperturate; pistil 1, unicarpellate, the ovary gradually narrowed into a short style, stigma apical; ovule 1, bitegmic, anatropous; fruit a berry; embryo small, linear, 0.3 the length of the endosperm, the cotyledons hardly differentiated; endosperm copious.

Composition: 1 genus, 1 species.

Distribution: China and Japan.

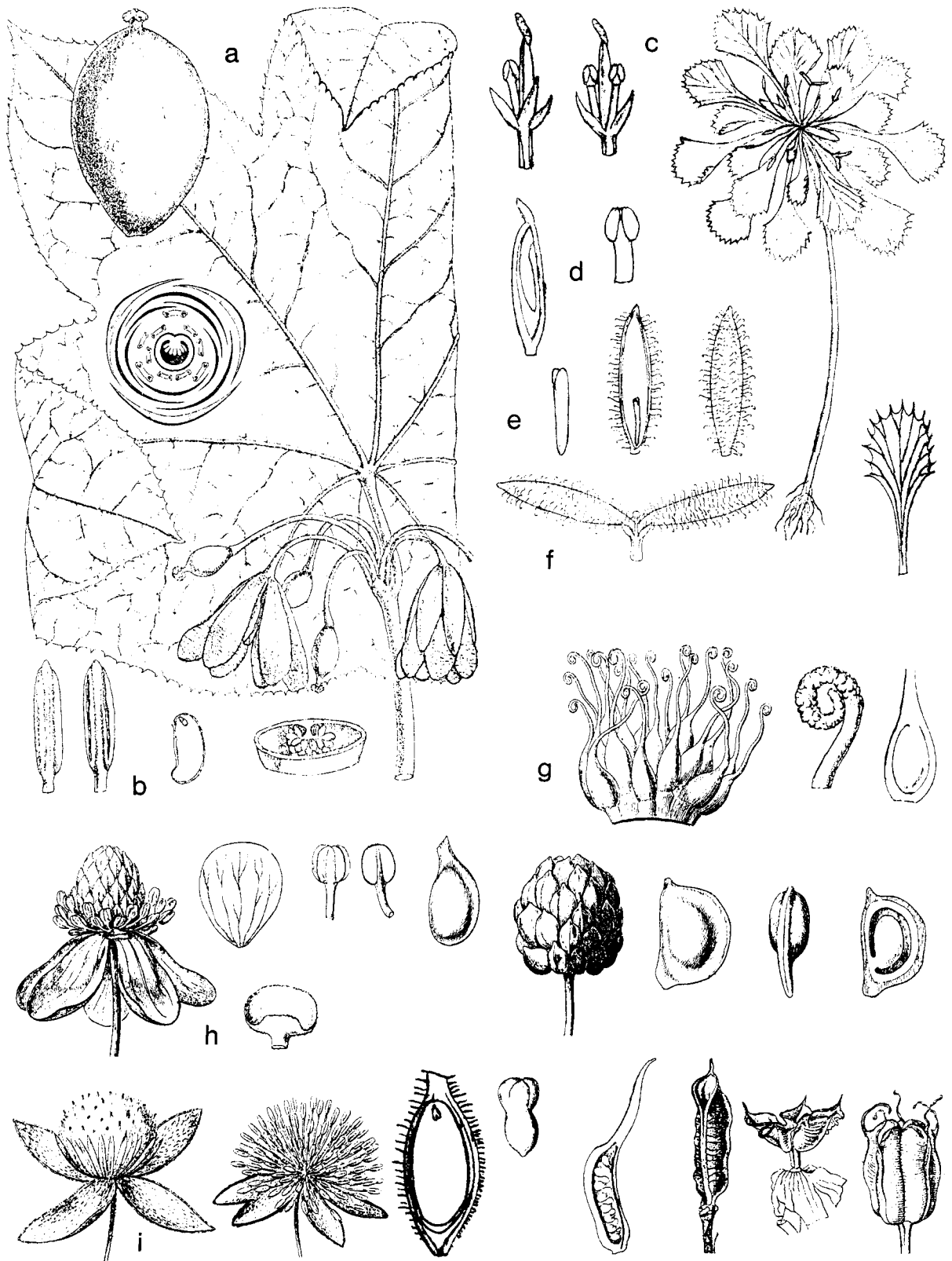
FIGURE 19.—**LARDIZABALACEAE:** *a*, *Lardizabala bitermata* floral diagrams of ♂ and ♀ flowers, ♂ flower, pistil, fruit, c.s. of ovary, l.s. of seed showing the minute embryo; *b*, *Akebia quinata* ♂ flower and l.s. of same, flowering twig, ♀ flower and l.s. of same, *Holboellia latifolia* l.s. of ♂ flower, l.s. of ♀ flower, floral diagram of ♀ flower (after Baillon, 1866–1895; Le Maout and Decaisne, 1873). **NANDINACEAE:** *c*, *Nandina domestica* flower, leaf and infructescence, floral diagram; *d*, infructescence, inflorescence in bud, leaf; *e*, fruit, flower bud, pistil, l.s. of same, views of stamen and androecium (after Steward, 1958; Hutchinson, 1973). **BERBERIDACEAE:** *f*, *Berberis laurina* bud, perianth from below, views of stamen before and at anthesis, infructescence; *g*, petal, pistil, l.s. of same, l.s. of seed showing different views of the embryo, fruit, l.s. of same, c.s. of same showing 2 seeds (after Martius 1840–1906).

BERBERIDACEAE (Figure 19*f,g*).—Shrubs and herbs; xylem vessel perforation plates simple, occasionally scalariform (*Berberis*) with few bars; vascular bundles sometimes scattered in the pith; leaves alternate, entire or serrate, pinnately compound, trifoliolate, simple, or pinnately 1–3-ternate, exstipulate, rarely stipulate (*Epimedium*); inflorescences cymes, racemes, spikes, fascicles, panicles or the flowers solitary; flowers bisexual, the parts hypogynous; sepals 6 (4), free; petals 6 (4), free, the perianth trimerous in 4 whorls or rarely dimerous, very rarely absent; nectaries on the base of 6 petals; stamens 6 (4–15), free, opposite the petals; anthers basifixed or adnate, dehiscing by valves, the connective not apically produced; pollen basically 3-colpate, spiraperturate? in *Berberis*, 6–12-rugate in *Ranzania*; pistil 1, unicarpellate (derived from 2–3 carpels?), the style short, stigma apical; ovules 1–several, basal, bitegmic, crassinucellar, anatropous; fruit a berry, rarely a capsule dehiscing by a transverse slit, very rarely a nutlet; pericarp sometimes disappearing before the seeds ripen; seeds sometimes arillate; embryo minute and roundish, linear or spatulate, 0.07 to as long as the endosperm; cotyledons undifferentiated to 0.7 the length of the embryo, sometimes thin, 1–3 times as broad as the radicle; endosperm copious, fleshy, or horny.

Composition: ~13 genera, ~500 species.

Distribution: Centered in temperate North America and Eurasia, extending through Central America and along the Andes to the southern tip of South America; northern Africa, the highlands of northeast Africa; southeastern Asia to Borneo.

PODOPHYLLACEAE (Figure 20*a,b*).—Herbs; xylem vessel perforation plates simple(?); leaves simple, subopposite, palmately lobed and serrate, exstipulate; inflorescence terminal cymes, fascicles, subumbels, racemes, spikes, panicles, or the flowers solitary; perianth parts 12 or 18 in 2 or 3 whorls, heterochlamydeous, honey-scales absent; stamens 12 (18), twice as many as the petals, the filaments elongated; anthers basifixed, dehiscing longitudinally by slits, the connective very



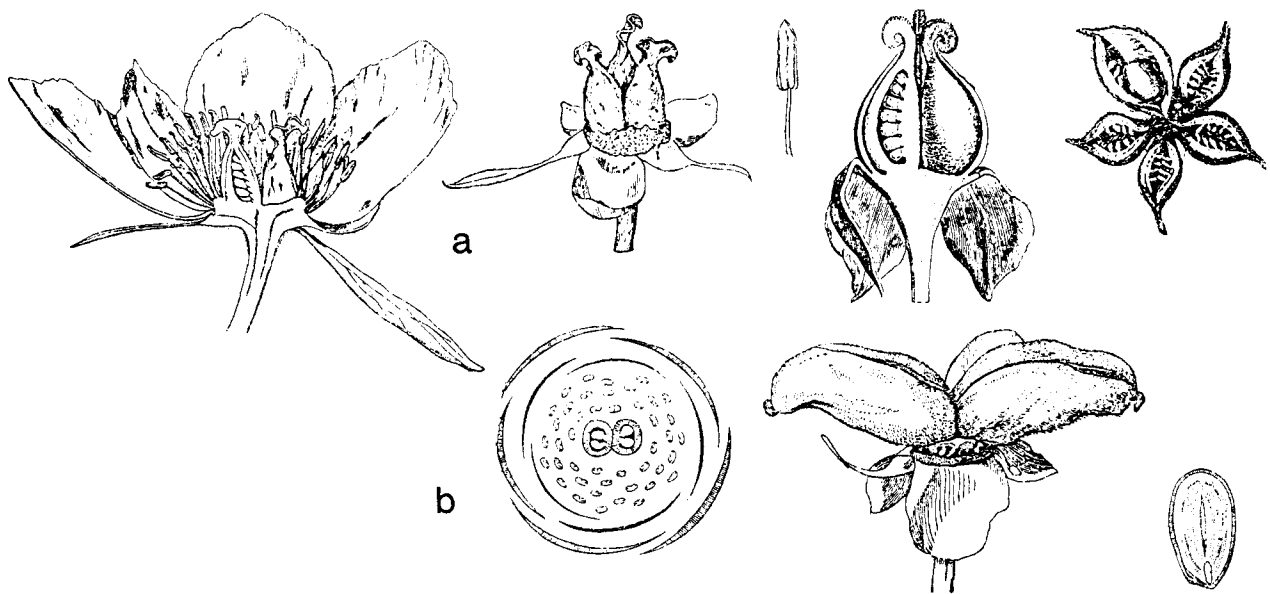


FIGURE 21.—PAEONIACEAE: *a*, *Paeonia officinalis* l.s. of flower, calyx and pistils, stamen, *P. moutan* l.s. of pistil, dehiscent fruitlets one with 1 seed; *b*, *P. officinalis* floral diagram, fruit, l.s. of seed showing the minute embryo (after Baillon, 1866–1895; Le Maout and Decaisne, 1873).

shortly apically produced; pollen 3-colpate (brevicolpate); pistil 1, unicarpellate, the ovules numerous, lateral, bitegmic, crassinucellar, anatropous; fruit a berry; embryo small, linear, 0.4 the length of the endosperm; endosperm copious, fleshy.

Composition: 2 genera, 9 species.

Distribution: Himalayas to China and Taiwan; eastern North America.

PAEONIACEAE (Figure 21*a,b*).—Herbs or shrubs; xylem vessel perforation plates scalari-

form with 2–5 bars; sometimes vascular bundles present in the pith; leaves alternate, biternate, with sublobed segments, exstipulate; flowers almost always solitary, bisexual, large, heterochlamydeous, the parts hypogynous; sepals 5, subfoliaceous; petals usually 5(–10); stamens numerous (45–75), free, spirally arranged, the filaments elongated; anthers oblong, basifixed, extrorse, dehiscent by longitudinal slits; pollen 3-colpor(oid)ate; glandular disk external to the pistils; pistils 2–5, large, the ovary tapering gradually into a short style, the stigma decurrent ventrally; ovules numerous, ventral, bitegmic, crassinucellar, anatropous; fruitlets follicular, the seeds large; embryo small, 0.1–0.2, the length of the endosperm, the cotyledons not broadened, 0.25 the length of the embryo; endosperm copious.

Composition: 1 genus, 33 species.

Distribution: Temperate Eurasia, especially China; southern Europe; northwestern United States.

RANUNCULACEAE (Figure 20*g–i*).—Herbs, rarely small shrubs or climbers; xylem vessel perforation plates simple, rarely also scalariform (*Hydrastis*); vessels frequently in several circles or

FIGURE 20.—PODOPHYLLACEAE: *a*, *Podophyllum versipelle* fruit, leaf and inflorescence, *P. peltatum* floral diagram. *b*, *P. versipelle* views of anther, l.s. of seed showing the minute embryo, c.s. of ovary (after Baillon, 1866–1895; Oliver). CIRCAEASTERACEAE: *c*, *Circaeaster agrestis* monandrous and diandrous flowers, plant in fruit; *d*, l.s. of pistil, stamen; *e*, embryo, l.s. of fruit, monocarpellary fruit; *f*, dicarpellary fruit, leaf (after Oliver). RANUNCULACEAE: *g*, *Anemone sellowii* gynoeceum, stigma, l.s. of ovary; *h*, *Ranunculus apūfolius* flower, sepal and petal, views of stamen, pistil, fruit, views of fruitlet and l.s. of same showing seed; *i*, *Clematis dioica* ♀ flower, ♂ flower, l.s. of fruitlet showing the minute embryo, embryo enlarged, *Trollius europaeus* l.s. of pistil, *Delphinium consolida* dehiscent fruit, *Eranthis hyemalis* fruit, *Nigella sativa* fruit (after Martius, 1840–1906; Schnizlein).

± irregularly scattered; leaves alternate and also basal, or rarely opposite, simple, serrate-crenate, sometimes lobed or compound, almost always exstipulate; inflorescence a cyme, raceme, panicle, thyrses, or the flowers solitary; flowers bisexual or rarely the plants dioecious or monoecious, the parts hypogynous; sepals (3–) 5–8, sometimes petaloid, rarely spurred; petals 5 (0–12) often with subbasal nectar gland(s), sometimes spurred, sometimes honey-scales between the perianth and stamens, rarely nectar secreted by the carpels (*Caltha*); stamens usually numerous (5–110), free, rarely the outer staminodal and petaloid; anthers usually small, about as long as wide, basifixed, the connective rarely apically produced, extrorse or introrse, dehiscent longitudinally by slits; pollen often 3-colpate, sometimes multiporate or nonaperturate; pistils usually numerous (to ~250) and spirally arranged, more rarely few and whorled, rarely only 1, rarely partially connate, the style short to elongated, the stigma decurrent ventrally or apical; ovules numerous to 1, ventral, 1–2-egmic, crassinucellar or tenuinucellar, anatropous or semi-anatropous; fruitlets achenes, follicles or rarely a berry, drupelets or capsule; embryo minute and rounded to linear, 0.07–0.3 the length of the endosperm; cotyledons undifferentiated to 0.6 the length of the embryo and 1.5 times the width of the radicle; endosperm copious, fleshy.

Composition: 50 genera, ~1900 species.

Distribution: Cosmopolitan, but centered in temperate and cold regions of the Northern and Southern Hemispheres, in various habitats but mainly moist; few tropical (*Clematis* spp.).

CIRCAEASTERACEAE (Figure 20c–f).—Small annual herb; xylem vessel perforation plates simple; leaves simple, dentate, the venation open and dichotomous, exstipulate, arranged in a rosette at the apex of the stem; flowers solitary in the upper leaf axils, bisexual, the parts hypogynous; sepals 2 (–3), valvate, persistent; petals 0; stamens 2 (1–3); anthers small, as long as wide, basifixed, the thecas separated by connective, not apically produced, dehiscent longitudinally; pollen 3-colpate; pistils 1–3, unicarpellate, the style

very short, stigma slightly elongated, the ovary uniovulate, the ovule unitegmic, tenuicellar(?), orthotropous; fruit an achene with uncinat prickle, the seeds minute; embryo linear, terete, straight, 0.3 the length of the endosperm; cotyledons not broadened, 0.2 the length of the embryo, linear-oblong in the seedling; endosperm copious.

Composition: 1 genus, 1 species.

Distribution: Temperate northwestern Himalayas to northwestern China.

HALORAGALES

Herbs, aquatic or of damp localities; xylem vessel perforation plates simple, the vascular tissue sometimes reduced to a weak axile bundle; leaves alternate or opposite, simple, often toothed, sometimes entire, usually small, stipulate or exstipulate; flowers minute, bisexual or unisexual; sepals 0 or 2–4; petals 0 or 2–4; stamens usually 1 or 2, more rarely to 8, in 1 or 2 whorls, the anthers basifixed; pollen 3-, 5–7-colpate, 3–5-rupoidate, 3–5-por(or)ate, 3–6-colpoidate or nonaperturate; pistil 1, the carpels 1–2(–4), styles elongate and stigmas decurrent or stigmas sessile; ovary usually inferior, 1–4-locular, the ovules 1 per locule; fruit 1–4 nutlets, drupelets, or mericarps; embryo minute to linear; endosperm usually scanty, rarely copious.

Distribution: Often cosmopolitan, most common in temperate regions, but some tropical and others in cold regions.

Chemistry: *Gunnera* stands apart from Haloragaceae. *Hippuris* seems chemically rather out of place in Myrtales. It has stachyose not reported in Myrtales and lacks ellagic acid so characteristic of that order. It has been suggested that the Callitrichaceae are related to the Lamiaceae, but the latter are rich in terpenoids, which are absent from the former.

HALORAGACEAE (Figure 22a,b).—Terrestrial or submerged herbs; xylem vessel perforation plates simple; leaves simple, small, opposite, alternate or whorled, serrate, the submerged leaves pectinately divided, exstipulate; flowers

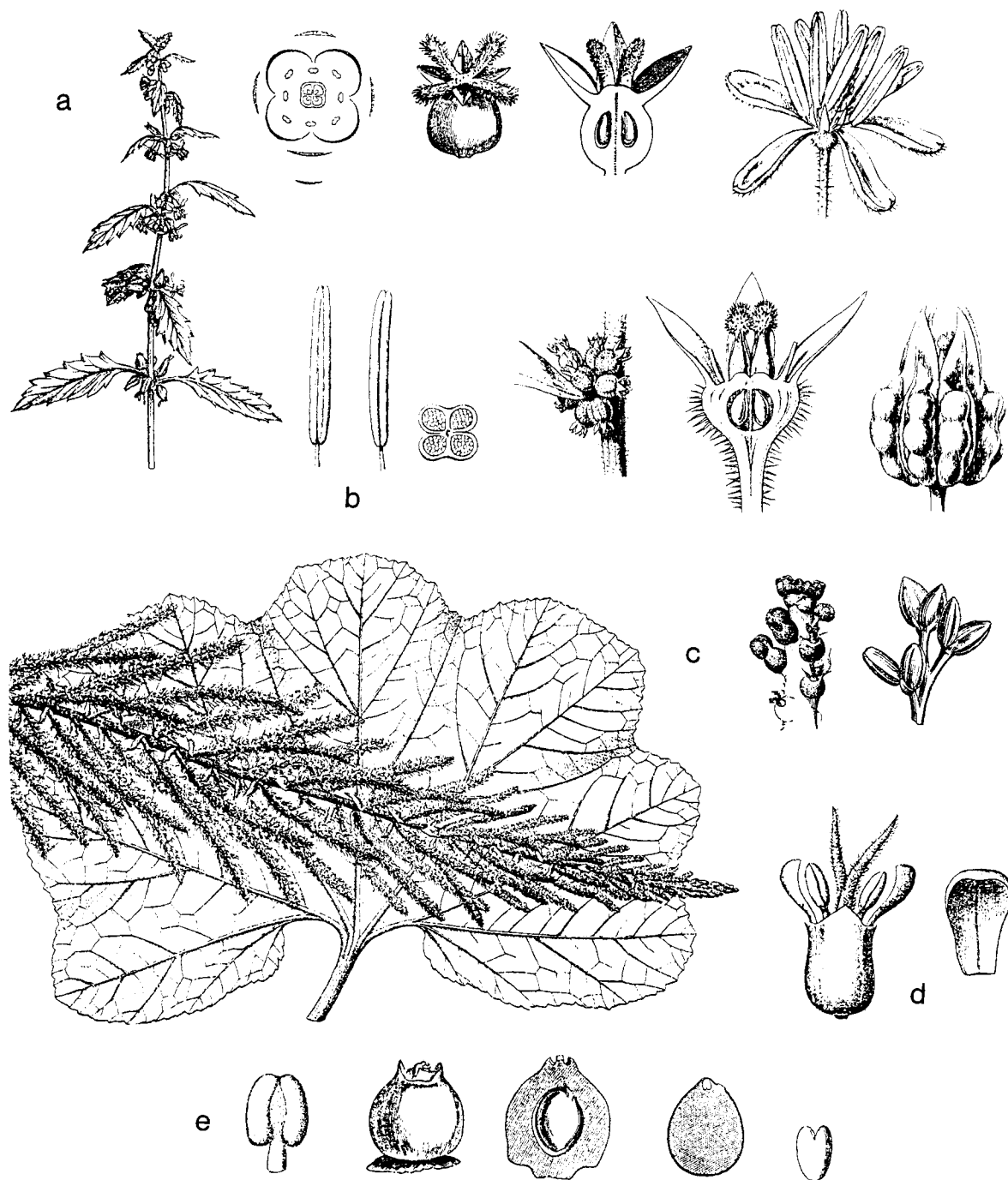


FIGURE 22.—HALORAGACEAE: *a*, *Haloragis erecta* flowering shoot, floral diagram, ♀ flower, l.s. of same, *Laurembergia coccinea* flower; *b*, views of stamen, c.s. of anther, inflorescence, l.s. of bisexual flower the anthers removed, *L. tetrandra* fruit (after Le Maout and Decaisne, 1873; Martius, 1840–1906). GUNNERACEAE: *c*, *Gunnera petaloidea* part of inflorescence and leaf, *G. chilensis* part of inflorescence, *G. scabra* ♂ flowers; *d*, *G. petaloidea* bisexual flower, petal; *e*, stamen, *G. scabra* fruit, l.s. of same, l.s. of seed showing the minute embryo, embryo enlarged (after Baillon, 1866–1895; Le Maout and Decaisne, 1873).

solitary or in fascicles and axillary, or in terminal spikes, racemes, or panicles, minute, bisexual or the plants monoecious; calyx-tube adnate to the ovary; sepals 2–4 or 0; petals 2–4 or 0; stamens 2–8, in 1 or 2 whorls; anthers basifixed, the connective sometimes apically produced; pollen 5–7-colpate, 3–5-rupoidate, 3–5-por(or)ate; pistil 1, the carpels 2–4, stigmas 2–4 subsessile, papillose or plumose; ovary inferior, 3–4-locular, the ovules 1 per locule, axile-subapical, bitegmic, crassinucellar, anatropous or semi-anatropous; embryo sac of the *Polygonum* type; fruit 1–4 nutlets; embryo linear, straight, terete, as long as the endosperm, the cotyledons 0.1–0.3 the length of the embryo; endosperm moderate or scanty, fleshy.

Composition: 6 genera, ~120 species.

Distribution: Cosmopolitan, especially Australia.

GUNNERACEAE (figure 22c–e).—Terrestrial or aquatic herbs, sometimes symbiotic with *Nostoc*; stems sometimes polystelic; xylem vessel perforation plates simple; leaves simple, small to very large, lobed and serrate, all radical; stipules large, axillary; inflorescence scapose, the flowers minute, often in dense clusters, bisexual or the plants monoecious or dioecious; sepals 2; petals 0; stamens 2, the anthers subsessile, basifixed, the connective not apically produced; pollen 3-colpate; pistil 1, bicarpellate; the styles 2, linear, stigmatic along most of their length; ovary inferior, unilocular, the ovule 1, apical, bitegmic, crassinucellar, anatropous, embryo sac tetrasporic of the 16 nucleate *Peperomia* type; fruit a drupelet or nutlet; embryo minute, 0.1 the length of the endosperm, the cotyledons not broadened, 0.4 the length of the embryo; endosperm copious.

Composition: 1 genus, ~35 species.

Distribution: Tropical and temperate; Mexico to Chile, including Juan Fernandez, reaching high in the Andes; Malaysia, Tasmania, New Zealand, Solomon Islands, Hawaii; tropical and South Africa.

HIPPURIDACEAE (Figure 23a,b).—Emergent aquatic herbs; vascular bundles concentric or an axile strand; leaves simple, linear, entire, veticil-

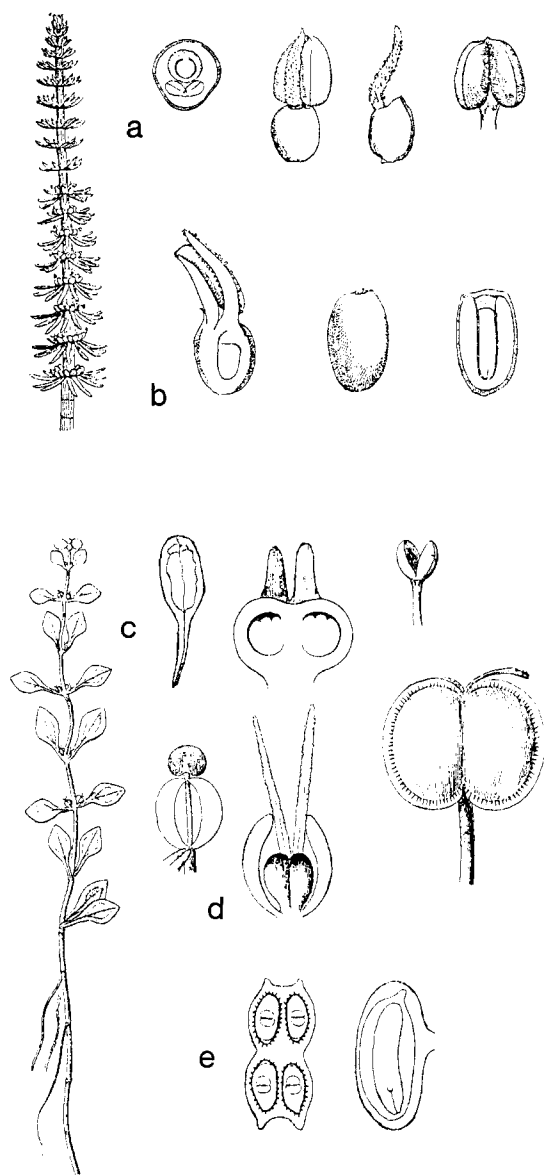


FIGURE 23.—HIPPURIDACEAE: a, *Hippuris vulgaris* flowering shoot, floral diagram, ♀ flower, pistil, stamen; b, l.s. of bisexual flower, fruit, l.s. of same (after Le Maout and Decaisne, 1873). CALLITRICHACEAE: c, *Callitriche verna* fruiting plant, *C. deflexa* leaf, *C. verna* l.s. of young ♀ flower, *C. deflexa* stamen; d, *C. verna* ♂ flower, ♀ flower with prophylls, *C. deflexa* fruit; e, c.s. of fruit showing embryo and endosperm (after Martius, 1840–1906).

late, exstipulate; flowers minute, solitary in the axils of the leaves, bisexual or rarely the plants monoecious or polygamous; perianth 0 or calyx merely a ring on the floral axis; stamen 1, epig-

ynous, the anther large, bilobed, basifixed; pollen 4–6-colpoidate(-colpate-colporoidate?); pistil 1, unicarpellate, the style subulate, stigmatic all along one side for its entire length; ovary inferior, the ovule 1, apical, unitegmic, tenuinucellar, anatropous; fruit an achene or drupelet; embryo linear, 0.9 to as long as the endosperm, the cotyledons 0.1–0.5 the length of the embryo; endosperm scanty.

Composition: 1 genus, 2 species.

Distribution: Temperate and arctic North America and Eurasia; southern tip of South America.

CALLITRICHACEAE (Figure 23c–e).—Small terrestrial or aquatic herbs, stems slender; vascular system a weak axile bundle; leaves simple, opposite, linear, entire, exstipulate; plants monoecious, the flowers minute, solitary or ♂ and ♀ in the same axil; perianth 0; stamen 1, subtended by 2 bracteoles, the filament filiform; anther small, as long as wide, basifixed; pollen nonaperturate or 3 (–4) colpoidate(?); pistil 1, bicarpellate, the styles 2, filiform, papillose along most of their length; ovary superior, 4-lobed, 4-locular, the ovules 1 per locule, axile, unitegmic, tenuinucellar, anatropous; fruit a schizocarp of 2 or 4 mericarps; embryo linear, terete, slightly curved, as long as the endosperm, the cotyledons 0.1–0.3 the length of the embryo; endosperm scanty, fleshy.

Composition: 1 genus, ~25 species.

Distribution: Almost cosmopolitan, centered in the temperate zones.

SARRACENIALES

The order is monotypic.

Chemistry: Gibbs considers that it is clear that the Sarraceniaceae and Nepenthaceae are chemically alike, but that the Droseraceae differ from them in important respects.

SARRACENIACEAE (Figure 24a–d).—Insectivorous herbs of bogs; rhizome xylem vessel perforation plates scalariform; leaves pitcher-shaped or tubular, usually hooded, radical; inflorescence scapose, a few-flowered raceme or the flower solitary; flowers bisexual, the parts hypogynous;

sepals 5 (3–6), free, imbricate, persistent, often colored; petals 5 (4–6) or 0, free; stamens ~80–12, free, the filaments considerably shorter than the pistil; anthers about as long as wide, dorsifixed, dehiscing longitudinally; pollen 5–9-colporoidate; pistil 1, the carpels 3 or 5 (–6), the style 1, 5-rayed toward the apex, or umbrella shaped, or shortly 3-lobed apically, the stigmas at the tips of the umbrella ribs or apical and papillose on the style arms; ovary 3 or 5(–6)-locular, the ovules numerous, axile, unitegmic or also bitegmic (?) (*Darlingtonia*), tenuinucellar, anatropous; fruit a loculicidal capsule, the seeds small, numerous; embryo linear, straight, 0.1–0.8 the length of the endosperm; cotyledons not broadened, 0.2–0.5 the length of the embryo; endosperm copious, fleshy.

Composition: 3 genera, 17 species.

Distribution: Eastern North America; California and Oregon; Guayana Highlands.

NEPENTHALES

The order is monotypic.

NEPENTHACEAE (Figure 24e,f).—Herbs and shrubs, often climbing; xylem vessel perforation plates simple, medullary and cortical bundles present in some species; leaves simple, entire, very rarely denticulate, some developing into insectivorous lidded ascidia, exstipulate; inflorescences terminal or axillary elongate racemes, sometimes with cincinnal branches, the plants dioecious; flowers small, actinomorphic; sepals 4 (3–6), usually imbricate in pairs, free or rarely basally connate, nectariferous on the inner surface; petals 0; stamens 8–24 (4–6) uniseriate or subbiseriate, the filaments connate into a column, the anthers 2-celled, apical, extrorse, about as long as wide or oblong, dehiscing longitudinally; pollen in tetrads, the apertures obscure, sexine spinuliferous; disk 0; pistil 1, the carpels 4 (3), the 4 (3) stigmas simple or bifid, sometimes capitate, apical, papillose, sessile or subsessile; ovary superior, 4(3)-locular, the ovules numerous, axile-septal, bitegmic, crassinucellar, anatropous; fruit a leathery loculicidal capsule, the seeds numerous, minute, usually bicaudate; em-

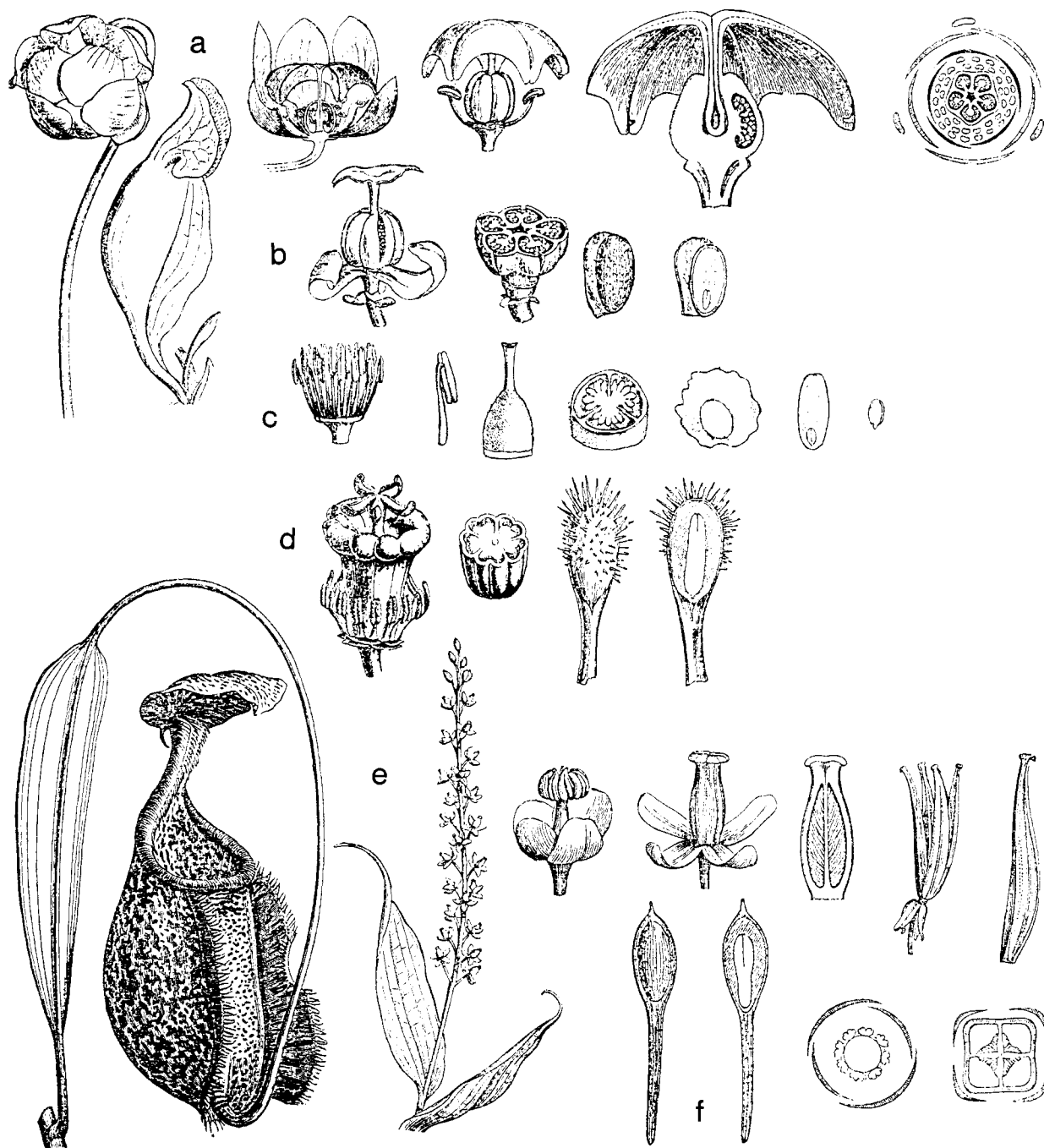


FIGURE 24.—SARRACENIACEAE: *a*, *Sarracenia purpurea* flower and scape, pitcher, l.s. of flower, pistil and 2 of the stamens, l.s. of pistil, floral diagram; *b*, dehiscent fruit, c.s. of same, seed and l.s. of same. *c*, *Heliamphora nutans* androecium, stamen, pistil, c.s. of ovary, seed, l.s. of seed, embryo; *d*, *Darlingtonia californica* essential organs, c.s. of ovary, seed and l.s. of same, (after Le Maout and Decaisne, 1873; Wunschmann). NEPENTHACEAE: *e*, *Nepenthes* sp. leaf terminating in a pitcher, *N. gracilis* ♀ inflorescence, *N. distillatoria* ♂ flower, ♀ flower, l.s. of pistil, *Nepenthes* sp. dehiscent fruit, valve of same; *f*, seed, l.s. of same, ♂ floral diagram, ♀ floral diagram (after Le Maout and Decaisne, 1873).

bryo straight, cylindrical, 0.8–0.9 the length of the endosperm; cotyledons linear, 0.4–0.8 the length of the embryo; endosperm copious, fleshy or starchy.

Composition: 1 genus, ~70 species.

Distribution: Wet tropical jungle; centered in Borneo, extending to southern China, Indochina, northern Australia, New Caledonia; Assam, Sri Lanka; Madagascar.

PIPERALES

Herbs, shrubs, and small trees, the stems often jointed and the tissues aromatic; xylem vessel perforation plates scalariform with very numerous bars to simple, rarely vessels absent; leaves alternate or opposite, simple, entire or toothed, stipulate or exstipulate; flowers minute or small, bisexual or unisexual; perianth absent or very rarely 3 sepals present; stamens 1–10, rarely in 2 whorls of 3 each, the anthers basifixed; pollen 1-sulcate, ulceroid or nonaperturate; pistils 1–4, the stigmas decurrent ventrally or a single sessile tuft; ovary 1–4-locular, the ovules 1–8 per placenta, axile or parietal; fruit drupelets, rarely small follicles or a ventricidal capsule; embryo minute; perisperm or endosperm copious.

Distribution: Most frequently in the understory of tropical rain forest, often in other wet habitats.

Chemistry: Piperales are rich in characteristic aromatic oils such as monoterpenes and sesquiterpenes, probably present in secretory cells. They have phenolic esters and ethers and a peppery taste. Alkaloids are prominent in Piperaceae but not in the other members of the order. Myristicin occurs in *Macropiper*.

SAURURACEAE (Figure 25a,b).—Perennial herbs of wet places, the stems jointed; xylem vessel plate perforations not clearly differentiated; tissues containing oil cells that give the plant a characteristic spicy fragrance; leaves alternate, simple, entire, the stipules united to the petiole; inflorescence terminal, a dense or loose spike or raceme, the upper leaves sometimes forming a white involucre; flowers small, bisex-

ual; perianth absent; stamens 3–8, free or adnate to the ovary, the filaments longer than the anther; anther slightly longer than wide, basifixed, the connective sometimes slightly apically produced; pollen 1-sulcate, occasionally faintly trichotomosulcate; pistils 3–4 sometimes connate basally or more completely, the styles free, the stigmas decurrent ventrally; ovary unilocular with parietal placentas or 3–4-locular with axile placentas, the ovules 1–8 per placenta, bitegmic, crassinucellar or tenuinucellar, orthotropous; fruit dehiscent into cocci, or a fleshy capsule dehiscent ventrally at the apex; embryo minute, 0.1 the length of the perisperm; cotyledons not differentiated; perisperm copious, starchy; endosperm scanty.

Composition: 5 genera, 7 species.

Distribution: Temperate and subtropical; United States, Mexico; Japan, China, Indochina, Philippines.

PIPERACEAE (Figure 25c).—Herbs, shrubs, or small trees, sometimes scandent, often with swollen nodes, the tissues containing oil cells which give the plant a characteristic pungent taste and odor; vascular bundles \pm scattered as in the monocots; xylem vessel perforation plates simple, or occasionally scalariform with few bars (*Piper*); leaves simple, usually alternate, sometimes opposite or verticillate, entire, often the main veins extending from the base of the leaf nearly to the apex, or the leaves succulent and the veins inconspicuous; stipules united to the petiole or absent; inflorescence leaf-opposed or axillary dense spike, or umbellate spikes, rarely a raceme (*Ottonia*); flowers minute, bisexual or unisexual; perianth absent; stamens 1–10 hypogynous (to perigynous?), the filaments short; anthers basifixed, the sacs united or spreading at the base; pollen \pm distinctly 1-sulcate (nonaperturate in *Peperomia*); pistil 1 with up to 5 short styles, the stigmas decurrent ventrally, or stigma a single sessile tuft; ovary unilocular, ovule 1, 1–2-tegmic, crassinucellar, orthotropous; embryo sac with 8–16 nuclei, or up to 100 antipodals; fruit a drupelet; embryo minute, 0.04–0.2 the length of the perisperm, the cotyledons 0.4 the length of the

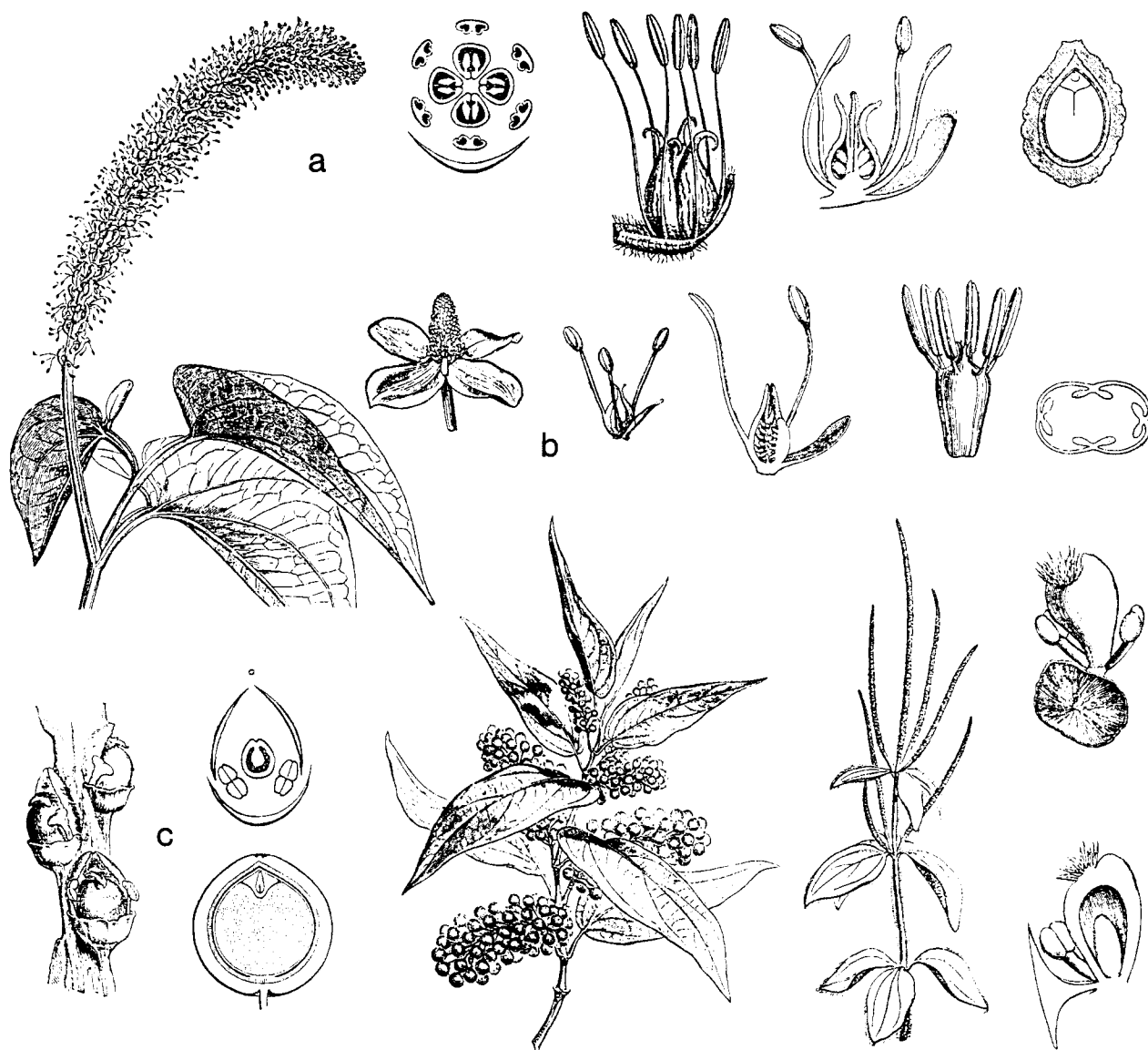


FIGURE 25.—SAURURACEAE: *a*, *Saururus cernuus* flowering stem, floral diagram, flower, l.s. of same, l.s. of fruit showing the minute embryo, endosperm and perisperm; *b*, *Houttuynia cordata* inflorescence, flower, l.s. of same, *Gymnotheca chinensis* flower, c.s. of ovary (after Baillon, 1866–1895; Le Maout and Decaisne, 1873). PIPERACEAE: *c*, *Piper nigrum* 3 flowers, floral diagram and l.s. of fruit showing the minute embryo, endosperm and perisperm, *P. cubeba* fruiting twig, *Peperomia blanda* flowering stem, flower and l.s. of same (after Baillon, 1866–1895).

embryo; perisperm copious, starchy; endosperm scanty.

Composition: 6 genera, ~1,500 species.

Distribution: Mostly in the understory of rain forest in tropical America, the West Indies and Africa; eastern Africa; Japan, China, India, the

East Indies, Australia, New Zealand; the woody species are especially Asiatic, the herbaceous (*Peperomia*) American.

LACTORIDACEAE (Figure 26*a,b*).—Shrubs with swollen nodes; xylem vessel perforation plates simple; leaves alternate, simple, distichous, small,



FIGURE 26.—LACTORIDACEAE: *a*, *Lactoris fernandeziana* flowering twig, base of blade and stipule, floral diagram, flower, l.s. of a carpel, the same cut open dorsally, c.s. of a carpel; *b*, anther, dehiscent fruit, dehiscent segment of same, seed, l.s. of same showing the minute embryo (after Hooker, Engler). CHLORANTHACEAE: *c*, *Sarcandra chloranthoides* part of flowering and fruiting twigs, part of inflorescence enlarged, flower further enlarged, pistil, l.s. of same, l.s. of fruit showing the minute embryo; *d*, *Hedyosmum arborescens* ♂ inflorescence, stamen, ♀ flower, l.s. of same, l.s. of fruit showing the minute embryo; *e*, *Chloranthus inconspicuus* l.s. of flower, stamens, c.s. of same, l.s. of fruit showing the minute embryo, embryo enlarged (after Baillon, 1866–1895; Le Maout and Decaisne, 1873; Wight).

emarginate, glandular-punctate, the stipules large, membranous, united to the petiole, and surrounding the twig; plant polygamo-monoecious; inflorescence axillary with 1–5 flowers; flowers small, the parts hypogynous; sepals 3;

petals 0; stamens in 2 whorls of 3 each; anthers subsessile, extrorse, the connective apically produced; pollen with 1 distal ulceroid aperture; pistils 3, the ovary grading into a small style, stigmatic ventrally near the apex; ovules ventral-

basal, 6–8 per pistil, bitegmic, tenuinucellar(?), anatropous; fruitlets follicles, 4–6 seeded, embryo minute, 0.1 the length of the endosperm; endosperm copious, oily.

Composition: 1 genus, 1 species.

Distribution: Juan Fernandez Islands of Chile.

CHLORANTHACEAE (Figure 26*c–e*).—Shrubs, trees, and herbs with aromatic tissues; xylem vessel perforation plates scalariform with very numerous bars, to 100 or more, or vessels absent; leaves opposite or subwhorled, simple, crenate or serrate, the stipules small; inflorescence spikes, heads, panicles or cymes; flowers minute, bisexual or pseudohermaphrodite or the plant monoecious or dioecious; ♂ perianth absent; stamens 1, or 3 with the middle anther bilocular and the laterals unilocular, the connective sometimes apically produced; stamens connate to one another and adnate to the ovary, or 50–250 free stamens in a *Hedyosmum* flower (inflorescence ?); pollen nonaperturate, 1-sulcate or polycolpoidate; ♀ calyx adnate to the ovary and minutely 3 dentate, or absent; pistil 1, the styles 3, very short, or the stigma sessile and not divided; ovary unilocular, the ovule 1, apical, bitegmic, crassinucellar, orthotropous; fruit a drupelet; embryo minute, 0.06–0.1 the length of the endosperm, the cotyledons divaricate, 0.4 the length of the embryo; endosperm copious, oily.

Composition: 5 genera, 65 species.

Distribution: Tropical and subtropical, from low elevations to high in mountains; America, Japan, China, India, the East Indies, New Zealand.

NYMPHAEEALES

Aquatic herbs; xylem vessels absent, the tracheids long in Nymphaeaceae; leaves usually alternate, often large, floating or emergent, stipulate or exstipulate; flowers minute to very large, usually bisexual; sepals 3–6; petals 3 to ~25 or rarely absent; stamens 5 to ~120, whorled or spirally arranged, the filaments sometimes laminar; anthers basifixed or adnate, elongate; pollen 1–4-sulcate, more rarely 3-colpate or nonaperturate;

pistils 1 to ~25, the carpels 1–35, style long and the stigma decurrent ventrally or the stigmas sessile and linear or apical; ovules 1–many, usually scattered over the ovary wall; fruit usually a berry or capsular syncarp, sometimes a nutlet; embryo minute or large; perisperm copious or absent.

Distribution: Almost cosmopolitan, but absent from cold regions.

Chemistry: Benzylisoquinoline occurs in *Nelumbo*, Magnoliales, Ranunculales, *Fagara* and one *Croton*. Aporphine occurs in *Nelumbo*, Magnoliales, and Ranunculales.

CERATOPHYLLACEAE (Figure 27*a,b*).—Plants submerged herbs, rootless; xylem vessels absent; leaves simple, verticillate, dichotomously divided into linear serrulate segments, exstipulate; plants monoecious; flowers minute, axillary, solitary; sepals (bractlets?) 8–15, basally connate in one whorl, hypogynous; petals 0; stamens 5–27, spirally arranged; anthers oblong, subsessile, adnate, the connective apically produced; pollen nonaperturate; pistil 1, unicarpellate, the style fairly long, the stigma decurrent ventrally; ovule 1, unitegmic, crassinucellar, orthotropous; fruit a nutlet; embryo large, the cotyledons oblong, the radicle shorter than the cotyledons, the plumule well developed; endosperm 0.

Composition: 1 genus, ~5 species.

Distribution: Cosmopolitan except in the colder parts of the Northern Hemisphere.

CABOMBACEAE (Figure 27*c,d*).—Aquatic herbs with laticiferous tubes or sacs in the parenchyma; xylem vessels absent; floating leaves alternate, peltate, entire, simple, the submerged ones opposite and finely dissected, exstipulate; flowers axillary, solitary, bisexual, the parts hypogynous; sepals 3, petaloid; petals 3; stamens 3–18, cyclic, the filaments longer than the anthers; anthers extrorse, about twice as long as wide, basifixed, the connective not apically produced; pollen 1-sulcate; pistils 1–18, the ovary grading into a short style, the stigma apical; ovules 1–3, bitegmic, crassinucellar, orthotropous, laminar (distant from the ventral suture); fruit nutlets; embryo minute, 0.07 the length of the per-

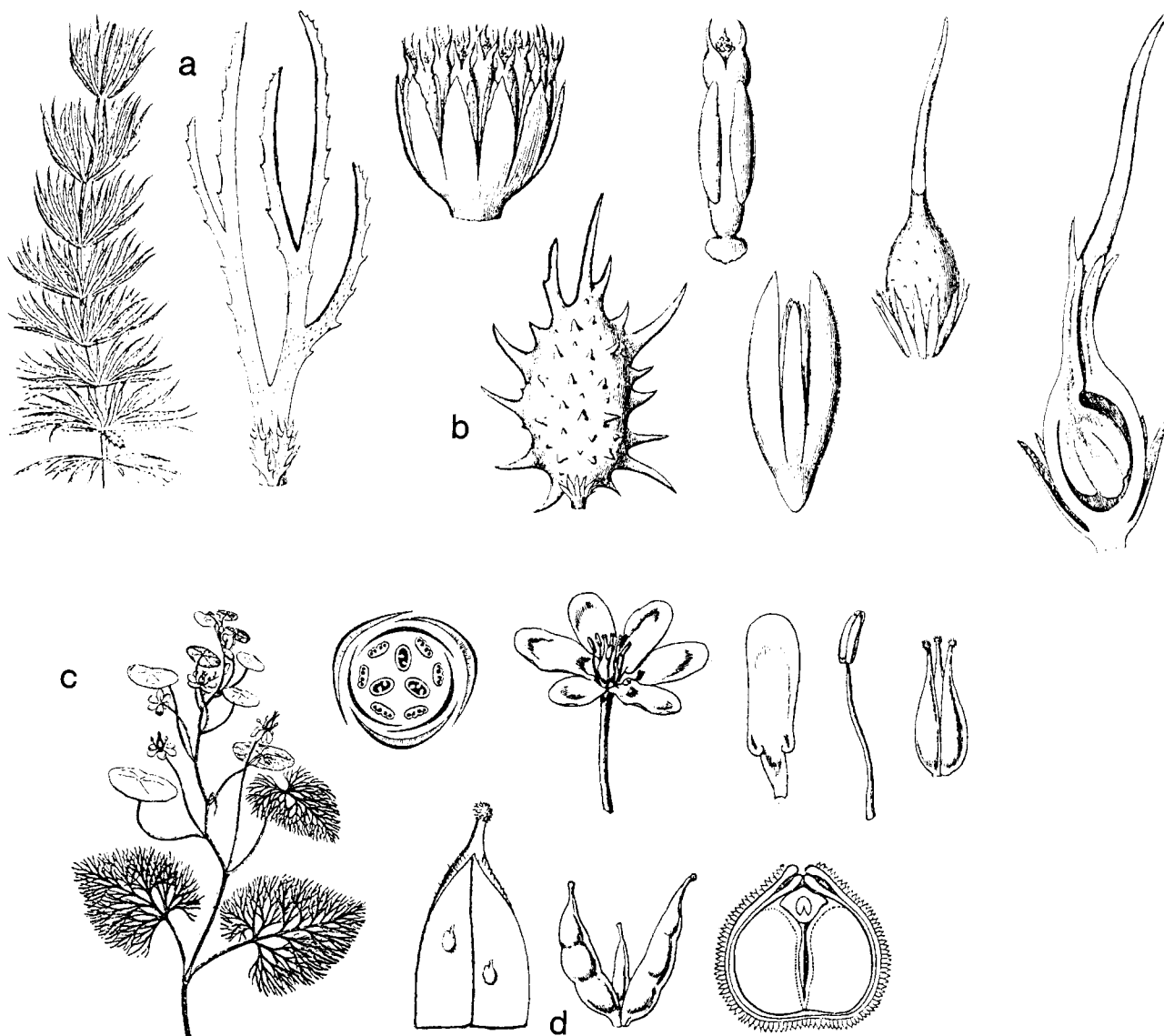


FIGURE 27.—CERATOPHYLLACEAE: *a*, *Ceratophyllum demersum* habit, leaf, ♂ flower, stamen, ♀ flower; *b*, fruit, embryo laid open, l.s. of pistil (after Martius, 1840–1906). CABOMBACEAE: *c*, *Cabomba aquatica* flowering shoot, floral diagram, *C. piauhyensis* flower, petal, stamen, pistils; *d*, *C. aquatica* pistil laid open, *C. piauhyensis* fruitlets, *C. aquatica* l.s. of seed showing the minute embryo, endosperm and perisperm (after Baillon, 1866–1895; Martius).

isperm, the cotyledons slightly differentiated; perisperm copious, starchy; endosperm scanty.

Composition: 2 genera, 7 species.

Distribution: Eastern North America to Argentina; eastern Asia, India, Australia; formerly in Europe.

NYMPHAEACEAE (Figure 28a–c).—Aquatic herbs with laticiferous tubes or sacs in the parenchyma and scattered vascular bundles; xylem vessels absent, tracheids long; leaves simple, radical, alternate, large, floating, peltate or cordate, entire or margin sinuate, sometimes stipu-

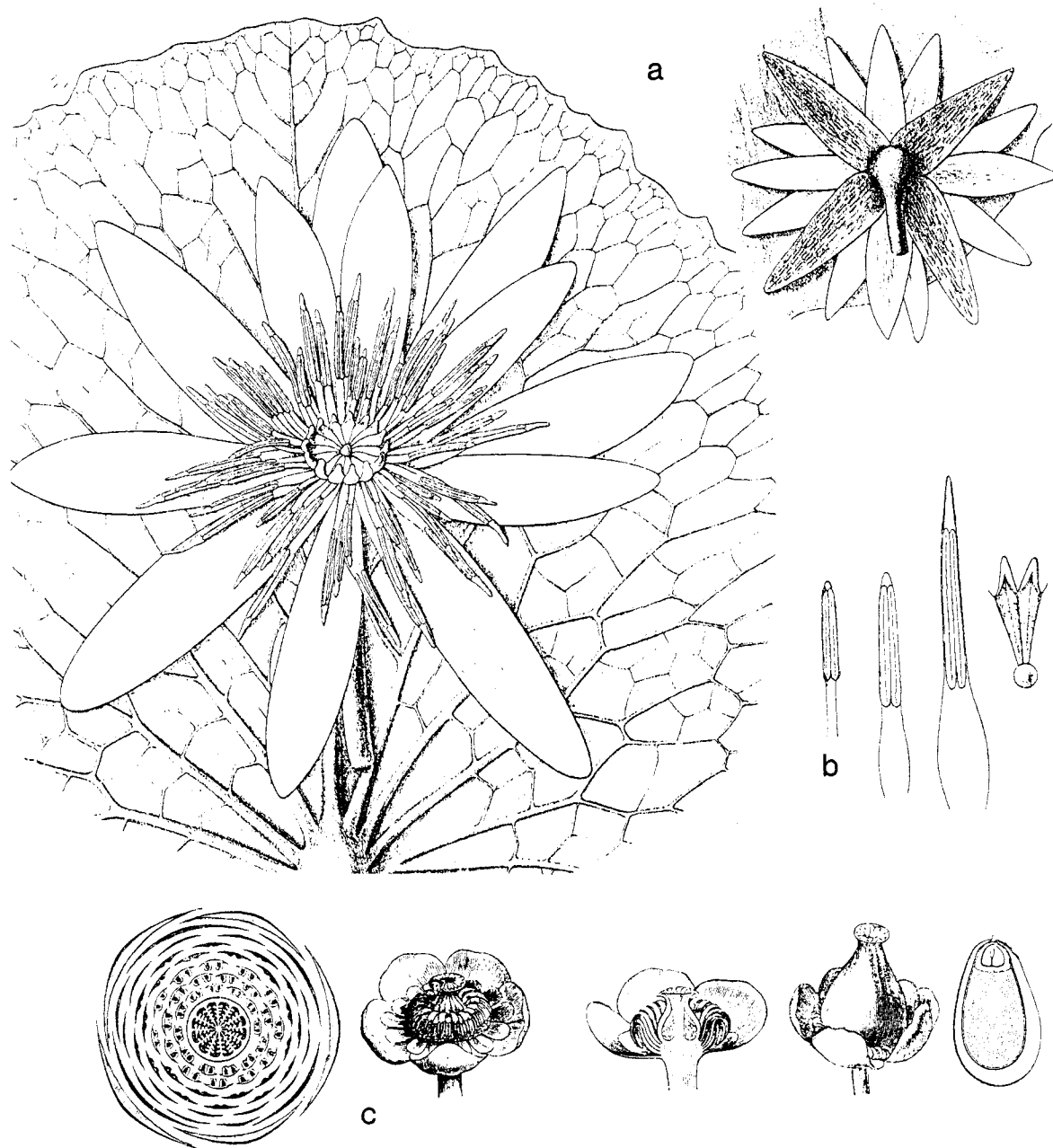


FIGURE 28.—NYMPHAEACEAE: *a*, *Nymphaea ampla* flower and part of a leaf, flower from below; *b*, inner, middle and outer stamen, 2 carpels viewed from above; *c*, *Nuphar luteum* floral diagram, flower, l.s. of same, fruit, l.s. of seed showing the minute embryo, endosperm and perisperm (after Martius, 1840–1906).

late; flowers solitary, bisexual, large, often fragrant, the parts hypogynous or perigynous; sepals 4–6, free or adnate to the receptacle; petals 5 to ~25, usually large, sometimes small and

scale-like (*Nuphar*), rarely absent (*Ondinea*), spirally arranged, sometimes nectariferous and grading into stamens; stamens (15–) 50–100, spirally arranged, the filaments often flattened;

anthers basifixed, the connective not apically produced; pollen \pm monocotyledonoid, 1–4-sulcate or zonisulcate, or nonaperturate(?); pistil 1, the carpels (3) 5–35, sometimes incompletely closed, the stigmas sessile, linear; ovary superior to inferior, the ovules numerous, parietal (scattered over the ovary walls), bitegmic, crassinucellar, anatropous; fruit a berry or capsular syncarp; embryo minute, 0.1–0.2 the length of the perisperm, the cotyledons undifferentiated; perisperm copious, starchy; endosperm scanty.

Composition: 5 genera, ~75 species.

Distribution: Temperate North America to tropical South America; temperate and tropical Asia, Africa and Australia, New Guinea.

NELUMBONACEAE (Figure 29a,b).—Aquatic herbs; xylem vessels absent; leaves simple, petiole, entire, floating or emergent, the stipule ochreate; flower solitary, the scape arising in the axil of a scale leaf, bisexual, the parts hypogynous; perianth entirely petaloid or sepals 4 and petals numerous (~20), spirally arranged; stamens numerous (100–120), spirally arranged; anthers linear, basifixed, the connective apically produced; pollen usually 3-colpate; pistils usually numerous (~6–25) embedded separately in an obconic receptacle, but not adnate, the style short, stigma apical; ovary uniovulate, the ovule bitegmic, crassinucellar, anatropous; fruit an achene or nutlet; embryo large, the cotyledons thick, plano-convex, the radicle invested, the plumule foliaceous; perisperm and endosperm 0.

Composition: 1 genus, 2 species.

Distribution: Eastern United States, Mexico, West Indies, Guayana to Colombia, Iran to eastern Asia; northern Australia.

PROTEALES

The order is monotypic.

Chemistry: Juglone occurs in Proteaceae.

PROTEACEAE (Figure 29c–f).—Trees and shrubs, rarely herbs; xylem vessel perforation plates typically simple, a few species with an occasional scalariform plate with few bars; leaves alternate, rarely verticillate or opposite, simple, entire, lobed, to deeply dissected, exstipulate;

inflorescences racemes, spikes, umbels or heads, rarely the flowers solitary, often subtended by an involucre of colored bracts; flowers usually bisexual, sometimes the plants dioecious or polygamous; sepals 4, free or basally connate, valvate, petaloid; petals 0; stamens 4, rarely 1 or 3 of these staminodal, opposite to and inserted upon the sepals, rarely hypogynous, the filaments rarely connate apically (*Symphyonema*); anthers oblong, dithecal, rarely some monothecal, basifixed, adnate or dorsifixed, sometimes apiculate, rarely connate (*Stirlingia*); pollen 3(2–5)-porate, 3-colpoidate, rarely 3-colpor(oid)ate(?); disk usually present, consisting of 4 (–2) alternisepalous glands or scales around the base of the ovary or gynophore, or sometimes connate; pistil 1, the carpel 1, style 1, long, filiform, the stigma apical or lateral near the apex of the style; gynophore sometimes present; ovary superior, unilocular, the placenta ventral, the ovules 1 or more, subbasal or subapical, bitegmic, the integuments developing very slowly and not enclosing the nucellus until after fertilization, crassinucellar, orthotropous, semi-anatropous or anatropous; fruit a nut, drupe or follicle; seeds often large, sometimes winged; embryo often large, the cotyledons sometimes 3–8, often unequal, thin or thick and plano-convex, 3–5.8 times wider than the radicle, 0.7–0.9 the length of the embryo and gradually grading into the radicle, the latter sometimes invested; endosperm 0 except in *Bellen-den*.

Composition: 62 genera, ~1,100 species.

Distribution: Most in warm, dry habitats, few in moist; centered in Australia and South Africa; Australia to New Zealand, the East Indies, Indochina, China, India, Japan; southern $\frac{2}{3}$ of Africa, Madagascar; Mexico to temperate South America.

BALANOPALES

The order is monotypic.

BALANOPACEAE (Figure 30a,b).—Trees or shrubs; terminal bud perulate; xylem vessel perforation plates scalariform, with numerous bars; leaves alternate, subopposite or subverticillate,

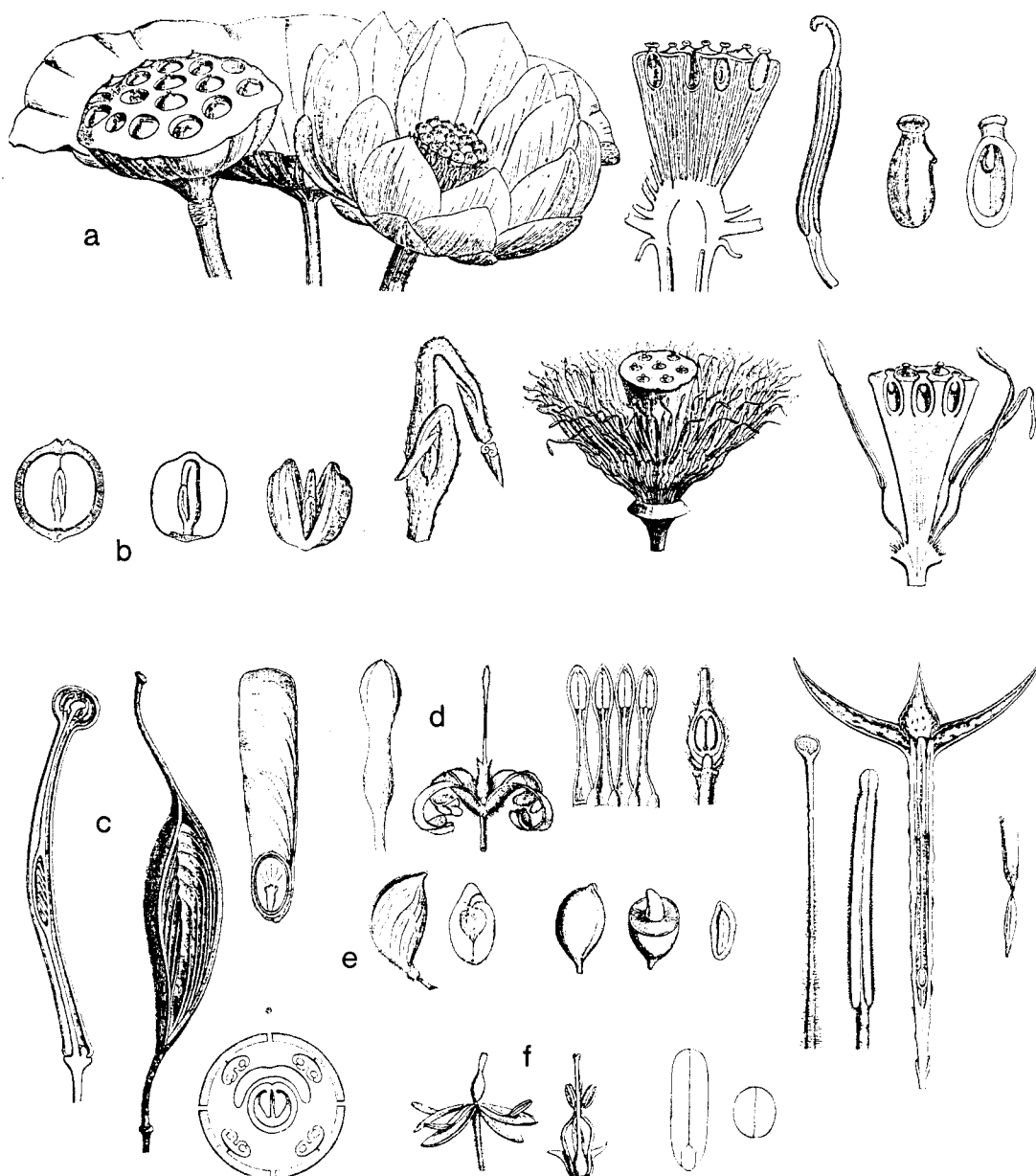


FIGURE 29.—NELUMBONACEAE: *a*, *Nelumbo lutea* receptacle containing fruits, leaf and flower, l.s. of receptacle and pistils, stamen, pistil, l.s. of same; *b*, l.s. of fruit, embryo with 1 cotyledon removed to show the plumule, embryo laid open, plumule enlarged showing young leaves, *N. nucifera* flower without the perianth, l.s. of same (after Le Maout and Decaisne, 1873; Baillon, 1866–1895). PROTEACEAE: *c*, *Embothrium (Oreocallis) grandiflorum* l.s. of bud, dehiscent fruit, l.s. of seed, floral diagram; *d*, *Roupala rhombifolia* bud, *R. brasiliensis* flower, calyx laid open to show insertion of stamens and hypogynous glands, l.s. of ovary and hypogynous glands; *e*, fruit, seed, *Persoonia ferruginea* fruit, same with upper half of fleshy part removed, l.s. of the stone showing the seed, *Franklandia fucifolia* upper part of style with stigma, anther, l.s. of flower, fruit with tuft of hair; *f*, *Bellendena montana* flower, *Symphyonema montanum* essential organs, *Grevillea* sp. l.s. and c.s. of embryo (after Baillon, 1866–1895; Martius, 1840–1906; Le Maout and Decaisne, 1873; Endlicher; Engler; Schnizlein).

simple, entire or obscurely crenate apically, exstipulate; plants dioecious, the flowers small, perianth absent; ♂ inflorescence in short, loose spikes below the leaves, the flower subtended by 2–6 scales; stamens 3–6 (1–12); anthers subsessile, oblong-ellipsoid, the connective often slightly apically produced; pollen 3–4(–5)-colpoidate; ♀ flower solitary, subtended by numerous imbricate bracteoles; pistil 1, the carpels 3 (–2), the styles 3 (–2), subulate, each 2-partite nearly to the base, the stigmas decurrent; ovary superior, 3(–2)-locular, sometimes incompletely so, each locule with 2 anatropous basal ovules; fruit an acorn-like drupe, nearly a nut, subtended by the involucre; pyrenes 1–2, each 1-seeded; embryo large, straight, spatulate, 0.85 the length of the endosperm, the cotyledons thin, plano-convex, 0.8 the length of the embryo; endosperm scanty, fleshy.

Composition: 1 genus, 10 species.

Distribution: Northeastern Queensland, New Caledonia, Fiji.

FAGALES

Trees and shrubs, sometimes aromatic due to resinous glands; xylem vessel perforation plates scalariform or simple; leaves usually alternate, simple or compound, entire, toothed or lobed, often exstipulate; plants dioecious or monoecious, the flowers minute, usually anemophilous, sometimes entomophilous, usually in catkins, rarely heads or a panicle; sepals or calyx lobes 3–6 or 0; petals 0; stamens 3–40 (–105), the filament often short, sometimes filiform, inserted on a bract or flattened receptacle, the anthers usually basifixed, sometimes dorsifixed; pollen 3–6 (7)-colpate or colporate, 3–16-porate to colporate, 3-porate; pistil 1, the carpels 1–3 (6), with as many styles, the stigmas usually decurrent ventrally, more rarely punctiform; ovary superior or inferior, 1–3-locular, the ovules 1–2 per locule; fruit a nut, drupe or samara, rarely a tardily dehiscent capsule; embryo large; endosperm absent or rarely scanty.

Distribution: Primarily north temperate to

tropical, more rarely south temperate or tropical, in wet to dry habitats.

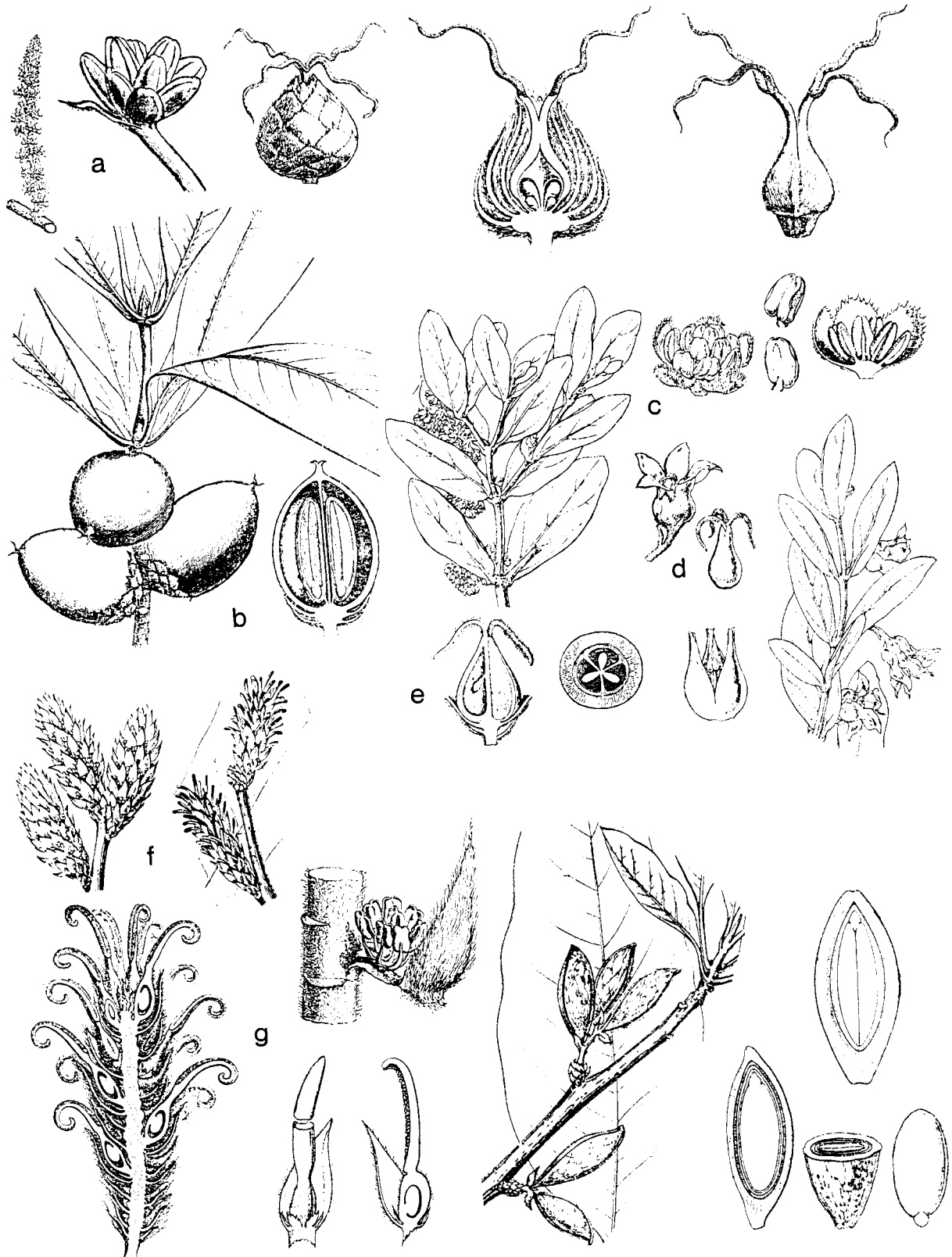
Chemistry: Chemical evidence is strongly in favor of relationship between Fagaceae and Betulaceae, including *Corylus*. Juglandaceae have amides and show the Betulaceae type of metabolism (show citrulin), but amides occur in a variety of families. Myricaceae are related to Betulaceae; both have members that develop blue-green or green color in the NH_3 layer of the Juglone test. This reaction has rarely been observed elsewhere. *Myrica* fat is said to have large amounts of myristic acid, as does the Myricaceae.

SIMMONDSIACEAE (Figure 30c–e).—Divaricate branched shrub; xylem vessel perforation plates simple; growth of stem in thickness by development of successive concentric rings of xylem and phloem, the rings separated by narrow circles of parenchyma; leaves opposite, simple, entire, exstipulate; plants dioecious; ♂ flowers in capitate clusters; sepals 5 (4–6); corolla 0; stamens 10–12, inserted on a flat receptacle, the anthers subsessile, oblong; pollen 3-colpate; ♀ flowers solitary, more rarely in a 2–7-flowered pendulous raceme; sepals 4–7, imbricate; corolla 0; pistil 1, the carpels 3, the styles 3, free, papillose, the stigma decurrent along the entire length of the style; ovary superior, 3-locular, the ovules 1 per locule, subapical, bitegmic, crassinucellar, anatropous; fruit an ovoid loculicidal capsule, with a thick beech-fruit-like surface; embryo large, the cotyledons large, thick, the radicle short, invested; endosperm 0.

Composition: 1 genus, 1 species.

Distribution: Dry habitats; southwestern United States and northwestern Mexico.

LEITNERIACEAE (Figure 30f,g).—Shrub; xylem vessel perforation plates simple; secretory canals with resinous contents in stem and leaves; leaves alternate, simple, entire, exstipulate; plants dioecious; ♂ inflorescence axillary, cymose, pendulous catkin-like spikes; ♂ flower: perianth absent; stamens 3–12, inserted on a bract; anthers subsessile, basifixed, slightly longer than wide; pollen 3 (–6)-colporate; ♀ inflorescence erect, a shorter



catkin than the ♂; perianth of 4 (3–8) minute scales; pistil 1, the carpel 1, the style elongated, stigma decurrent all along the ventral surface; ovary superior, the ovule 1, ventral, integuments 2 (1?), crassinucellar, amphitropous or subanatropous; fruit a drupe with scanty flesh and a stony endocarp; embryo large, straight, spatulate, 0.9 the length of the endosperm, the cotyledons flat, fairly thick, 0.7 the length of the embryo; endosperm scanty, fleshy.

Composition: 1 genus, 1 species.

Distribution: Swampy areas; southern Missouri to Texas and Florida.

MYRICACEAE (Figure 31*a,b*).—Aromatic trees and shrubs; xylem vessel perforation plates exclusively scalariform or sometimes also simple; leaves alternate, simple, entire, dentate or pinnately lobed, with sessile, resinous glandular hairs, stipulate or exstipulate; plants monoecious, dioecious or polygamous; inflorescences axillary, simple, more rarely compound, catkin-like spikes; ♂ flower without a perianth; stamens 4–8 (2–16) inserted on a bract, the filaments short, sometimes a pair connate, the anthers basifixed, as long as wide; pollen 3-porate; ♀ inflorescence erect, very short, the flowers sometimes provided with sepal-like bracteoles; pistil 1, carpels 2, the styles 2, filiform, the stigmas decurrent along ventral surface of styles; ovary superior, unilocular, the ovule basal, unitegmic, crassinucellar, orthotropous; fruit a drupelet or nutlet, often covered with waxy warts, the endocarp bony; embryo straight, the cotyledons thick, plano-convex, 3.5–3.7 times wider than the radicle, 0.7–

0.9 the length of the embryo, the radicle partly invested; endosperm 0.

Composition: 3 genera, 40 species.

Distribution: Temperate and subtropical, in wet and dry habitats; America, northeastern Siberia to China and India, Indochina, the East Indies, New Caledonia, tropical and southern Africa; northwestern Europe.

JUGLANDACEAE (Figure 31*c–f*).—Aromatic resinous trees lacking resin vessels; xylem vessel perforation plates usually simple, 2 genera have scalariform plates with few bars; sieve tubes sometimes with lateral sieve areas, recalling those of gymnosperms; leaves alternate or rarely opposite (*Alfaroa*, *Engelhardtia* spp.), pinnately compound, the leaflets serrate or rarely entire, with shortly stalked resin-secreting peltate glands, exstipulate; plants monoecious (dioecious in *Engelhardtia* spp.); ♂ inflorescences usually catkins (few flowers in *Alfaroa*), erect or pendulous, 1–8 in a cluster; ♂ flower calyx 3–6-lobed or absent, adnate to a bract; stamens 3–40 (–105), the filaments short, inserted on the flattened receptacle; anthers basifixed, slightly longer than wide, the connective sometimes apically produced; pollen 3–16-porate to colpate; ♀ inflorescence a spike or the flowers subsolitary, pendulous or erect; ♀ flower calyx 4-toothed, adnate to the ovary; pistil 1, the carpels 2 (3–4 in an occasional flower), the style usually with 2 large branches, plumose and stigmatic on the ventral surface; ovary inferior, 1 (–2) locular, the ovule 1, basal, unitegmic, crassinucellar, orthotropous; fruit a nut or samara; embryo usually large, the cotyledons thick, broad, and often much contorted, 0.75–0.9 the length of the embryo and investing the radicle, the plumule evident, sometimes the cotyledons thin and folded toward the apex (*Engelhardtia*, *Pterocarya*); endosperm 0.

Composition: 7 genera, ~50 species.

Distribution: Primarily north temperate and subtropical; United States to temperate South America, extending furthest south along the Andes; southeastern Europe to India, China, Indochina, the East Indies, Japan.

RHOIPTLEACEAE (Figure 32*a,b*).—Tree; xylem vessel perforation plates exclusively scalariform

FIGURE 30.—BALANOPACEAE: *a*, *Balanops vieillardii* ♂ catkin, ♂ flower, ♀ flower, l.s. of ♀ flower, pistil; *b*, part of fruiting twig, l.s. of fruit (after Baillon, 1866–1895). SIMMONDSIACEAE: *c*, *Simmondsia chinensis* ♂ flowering twig, ♂ flower, views of stamen, l.s. of ♂ flower; *d*, ♀ flower, pistil; *e*, l.s. and c.s. of pistil, dehiscent fruit with aborted ovules (seed not present), ♀ flowering twig (after Le Maout and Decaisne, 1873; Nuttall). LEITNERIACEAE: *f*, *Leitneria floridana* ♂ inflorescences, ♀ inflorescences; *g*, l.s. of ♀ inflorescence, ♂ flower, ♀ flower with bract and involucre, the style cut across, l.s. of ♀ flower, fruiting twig, l.s. in 2 planes and c.s. of fruit, embryo (after Sargent; Baillon, 1866–1895).



form with 4–11 bars; leaves alternate, pinnately compound, serrate, glandular beneath and aromatic, stipulate; inflorescences large, lax axillary and terminal panicles, the flowers in clusters of 3 (1 bisexual and 2 sterile ♀); sepals 4 (2 interior and 2 exterior), free; petals 0; stamens 6, the filaments shorter than the anthers; anthers basifixed, oblong, slightly longer than wide, the thecas separate at apex and base; pollen 3-colporate, brevicolpate, granulate; disk 0; pistil 1, the carpels 2, the styles 2, short; ovary superior, bilocular, one locule aborting, the other with 1 axile ovule; fruit a small samara; embryo straight, the cotyledons ellipsoid, thick, 2.7 times wider than the radicle, 0.7 the length of the embryo; endosperm 0.

Composition: 1 genus, 1 species.

Distribution: Southwestern China, Indochina.

FAGACEAE (Figure 32*c,d*).—Trees and shrubs, the buds perulate; xylem vessel perforation plates predominantly scalariform to simple; leaves alternate, very rarely whorled, lobed, dentate, crenate or entire, rarely with sessile resinous glands (*Castanea japonica*), stipulate; plants monoecious, rarely dioecious (*Nothofagus*) or bisexual; ♂ inflorescences usually catkin-like spikes or heads, ♂ flower calyx 4–6(–7)-lobed; corolla 0; stamens 4–40, the filaments free, filiform, the anthers basifixed or dorsifixed; pollen 3–6(–7)-

colpate or colporate; ♀ flowers solitary or in dichasia or spikes, 1–7 (or more) in an involucre; calyx 4–6-lobed, adnate to the ovary; corolla 0; pistil 1, the carpels 3 (6), the styles 3 (6), linear or filiform, the stigmas decurrent to punctiform; ovary inferior, the locules 3 (6), the ovules 2 per locule, axile, 1–2-tegmic, crassinucellar, anatropous; fruit a nut, partly to completely enclosed in the involucre; embryo large, the cotyledons thick and plano-convex, or thin and folded, 0.8–0.9 the length of the embryo, the radicle invested; endosperm 0.

Composition: 8 genera, ~900 species.

Distribution: Widespread in temperate and subtropical Northern Hemisphere; mainly in mountains in tropical regions; one genus occurs in New Guinea, southeastern Australia, New Zealand, and southwestern South America; Mediterranean region of Africa.

BETULACEAE (Figure 32*e–h*).—Trees and shrubs, the buds perulate; xylem vessel perforation plates scalariform, sometimes with more than 20 bars; leaves alternate, simple, serrate, sometimes with sessile resinous glands, stipulate; plants monoecious; inflorescences pendent catkins or the ♀ sometimes an erect short dichasial spike; ♂ flower: Calyx membranous, usually 4 (1–5) partite or absent; stamens (1–) 2–6, inserted on a bract, the filaments very short; anthers oblong, basifixed?, the thecas connate or separate; pollen often aspidote, 3(–7)-poroid; ♀ flower: perianth absent or adnate to the ovary; pistil 1, the carpels 2, the styles 2, filiform; ovary inferior or naked, bilocular, the ovules 2–1 per locule, axile, unitegmic, crassinucellar, anatropous; fruit a nutlet or samara; embryo straight, as long as the seed; cotyledons moderately to very thick and plano-convex, 4–5.5 times wider than the radicle, 0.8–0.9 the length of the embryo, the radicle sometimes invested; endosperm 0.

Composition: 6 genera, species ~150.

Distribution: Dry and wet habitats; temperate Northern Hemisphere, extending into the arctic and subtropical zone; Andes to Bolivia.

FIGURE 31.—MYRICACEAE: *a*, *Myrica gale* twig with ♀ inflorescences, twig with ♂ inflorescences, *M. californica* inner and outer views of staminate flower with scale and bractlets, ♀ flower with scale and bractlets, l.s. of pistil, l.s. and c.s. of fruit, *M. asplenifolia* l.s. of ♀ flower with scale and bractlets; *b*, *M. aethiopica* twig with ♀ and ♂ flowers, *M. gale* l.s. of fruit, *Comptonia* sp. inner and outer views of ♀ flower, l.s. of fruit, embryo (after Sargent; Baillon, 1866–1895; Engler; Le Maout and Decaisne). JUGLANDACEAE: *c*, *Juglans regia* ♂ inflorescence, ♀ inflorescence, ♀ flower, diagram and l.s. of same, ♂ flower and l.s. of same, stamen; *d*, fruit, same with husk removed, seed, l.s. of same; *e*, *Carya myristicaeformis* fruiting twig, *Platycarya strobilacea* ♀ flowers with staminodes, l.s. of ♀ flower, ♀ strobilus; *P. chinensis* ♀ flower, ♂ flower; *f*, fruit, l.s. of same, *Pterocarya fraxinifolia* fruit, *Engelhardtia spicata* young fruit with 3-lobed bract (after Baillon, 1866–1895; Le Maout and Decaisne, 1873).

SALICALES

The order is monotypic.

SALICACEAE (Figure 33a,b).—Trees, shrubs, and subshrubs; xylem vessel perforation plates simple; leaves simple, deciduous, alternate, crenate, stipulate, the buds perulate; inflorescences erect or pendulous catkins, the plants dioecious, rarely individual specimens monoecious or the flowers bisexual; perianth absent; ♂ flowers sometimes with a cupular disk, sometimes with 1–2 small linear glands; stamens 2–3 (–60), the filaments free, rarely connate, filiform, long; anthers slightly longer than wide, basifixed or dorsifixed near the base; pollen non-aperturate, 3-colporoidate or 3-colporate; ♀ flowers with distinct glands or a cupule which is sometimes fleshy; pistil 1, the carpels 2 (–4), the styles 2 (–4), short or long, stigmatic ventrally; ovary 1-locular with 2–4 parietal or basal placentas, the ovules few –∞, 1(2)-tegmic, crassinucellar, anatropous; fruit a loculicidal 2–4-valved capsule; seeds small or minute, enveloped in fine hair; embryo straight, the cotyledons 3.3 times as wide as the radicle, 0.5–0.8 the length of the embryo; endosperm 0.

Composition: 2 genera, ~350 species.

Distribution: Centered in temperate Northern Hemisphere, extending into the arctic zone; commonly in moist habitats and on mountains; few in the Southern Hemisphere, absent from Australia.

CASUARINALES

The order is monotypic.

Chemistry: Casuarinales have hinokiflavone, a biflavonyl reported elsewhere only in gymnosperms, but biflavonyls occur in several other unrelated families. *Casuarina* and gymnosperms have estolide waxes.

CASUARINACEAE (Figure 33c–e).—Trees and shrubs with longitudinally grooved, jointed branchlets; xylem vessel perforation plates simple, occasionally also scalariform, with 2–30 bars; leaves scale-like, reduced to a 4–16-toothed sheath; plants monoecious or dioecious; inflorescence terminal, the ♂ usually a spike, the ♀ a head; perianth 0 (2 sepals in ♂ flower?), the flowers bracteolate, in a cup-like involucre; stamens 1, the filament elongate at anthesis; anther about 1.5 times longer than wide, basifixed; pollen 3(2–5)-pororate; pistil 1, the carpels 2, one aborting, the style with 2 filiform branches, stigma decurrent; ovary superior, initially 2-locular, unilocular at anthesis, ovules 2 (–4), collateral, axile, bitegmic, crassinucellar, orthotropous or ± anatropous; bracts and bracteoles hardening into a cone; fruit samaras enclosed in woody bracteoles; embryo straight, the cotyledons thin, 3.2 times wider than the radicle, 0.8 the length of the embryo; endosperm 0.

Composition: 1 genus, ~50 species.

Distribution: Mainly in dry habitats; centered in Australia, extending to the East Indies, Malaya, New Caledonia, and Fiji.

URTICALES

Trees, shrubs, and herbs, sometimes with tough fibers or laticiferous; xylem vessel perforation plates simple, rarely also with a few bars; leaves usually alternate, simple, usually serrate, sometimes lobed, usually stipulate; flowers minute, usually anemophilous, the plants usually monoecious or dioecious, more rarely the flowers bisexual; sepals 0–5 (–8), sometimes connate; petals 0; stamens 4–10 (1–12), the filaments short or elongate, anthers basifixed or dorsifixed, the connective sometimes apically produced; pollen

FIGURE 32.—RHOIPTLEACEAE: a, *Rhoiptelea chiliantha* bisexual flower, pistil, anther; b, fruit, c.s. of same, stipule, fruiting twig (after Hutchinson). FAGACEAE: c, *Quercus robur* twig with ♀ inflorescences, ♂ inflorescences, ♀ flower, l.s. of same, ♂ flower, fruit, l.s. of same, *Fagus sylvatica* c.s. of fruit, *Castanea vulgaris* flowering twig; d, ♀ flower, l.s. of same, ♂ flower, l.s. of same, *Nothofagus cliffortioides* ♂ flower, *N. gunnii* fruits, *Castanea vulgaris* ♂ and ♀ inflorescences (after Baillon, 1866–1895; Le Maout and Decaisne, 1873; Hooker and Hooker, 1837–1982). BETULACEAE: e, *Corylus avellana* twig with ♀ and ♂ inflorescences, ♀ inflorescence, l.s. of young fruit; f, ♂ flower, fruits enveloped by accrescent bracteoles; g, *Betula pumila* scale with 3 ♂ flowers, ♂ flower, *Alnus cordifolia* scale with 2 ♀ flowers, l.s. of fruit; h, *Carpinus betulus* stamen, bract with fruit, l.s. of fruit (after Baillon, 1866–1895; Le Maout and Decaisne, 1873).

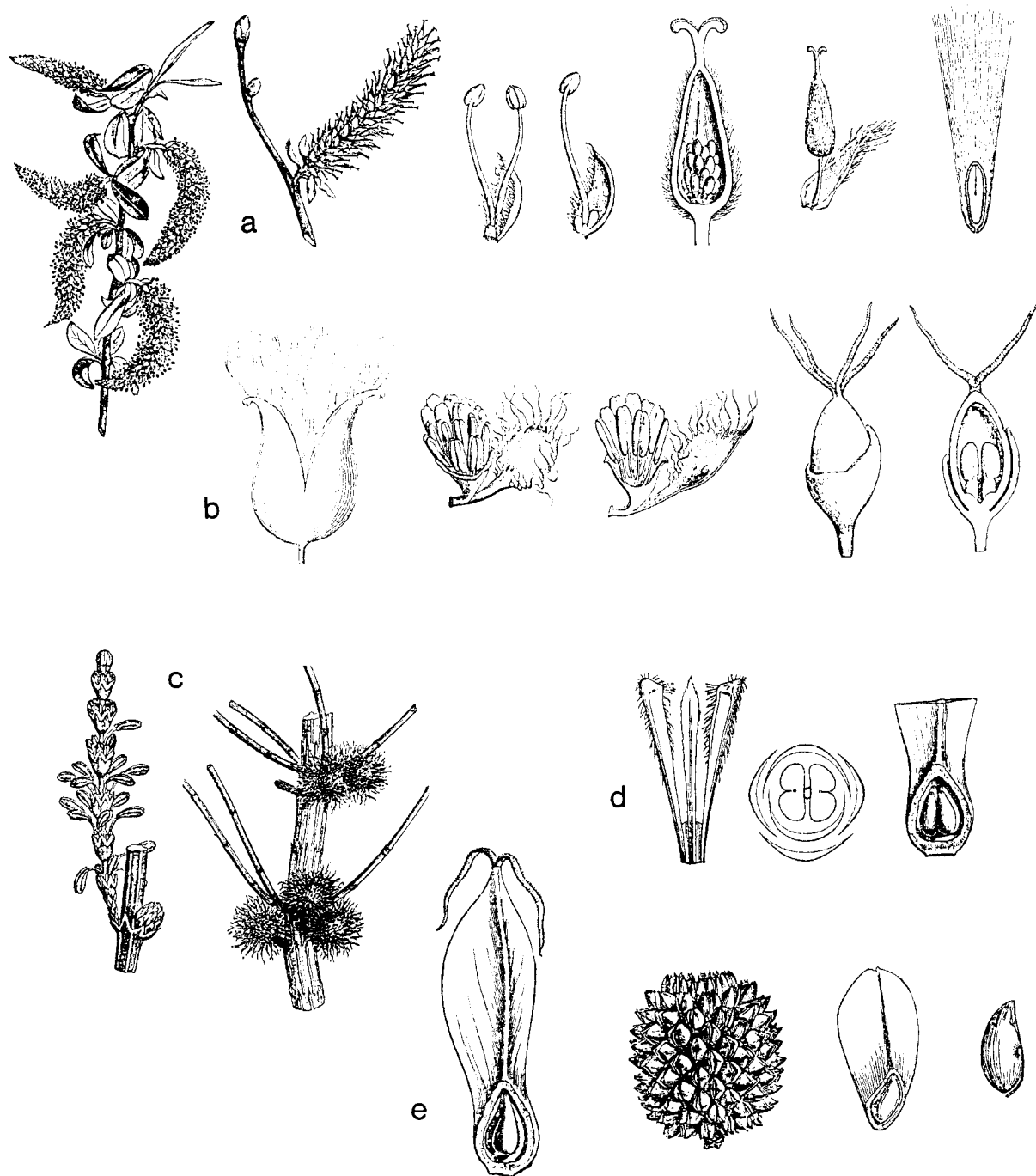


FIGURE 33.—SALICACEAE: *a*, *Salix alba* twig with ♂ inflorescences, ♀ inflorescence, ♂ flower, l.s. of same, l.s. of pistil, ♀ flower, l.s. of seed; *b*, *S. humboldtiana* dehiscent fruit, *Populus nigra* ♂ flower, l.s. of same, *P. nivea* ♀ flower, l.s. of same (after Baillon, 1866–1895; Martius, 1840–1906). CASUARINACEAE: *c*, *Casuarina quadrivalvis* ♂ inflorescence, ♀ inflorescences; *d*, ♂ flower (bracts) with anther removed, *C. nodiflora* diagram of ♂ flower, *C. angulata* l.s. of ovary; *e*, *C. equisetifolia* ♀ flower with ovary opened to show ovules, *Casuarina* sp. fruiting strobilus, fruit cut to show the seed, seed (after Baillon, 1866–1895; Le Maout and Decaisne, 1873).

3-colporate or -colpate, or 3 (2–15)-porate; pistils 1–3, the carpels 1–3, styles 1–3, the stigmas decurrent ventrally or short or fimbriate; ovary superior, 1(2)-locular, the ovules 1, more rarely 2; fruit a nutlet or samara, more rarely a drupelet, achene or multiple fruit; embryo large, endosperm usually scanty or absent, rarely copious.

Distribution: Cosmopolitan, most abundant in the tropics, in moist to dry habitats.

Chemistry: Cardenolides and rubber are prominent in Moraceae. The Ehrlich test is + in Eucommiaceae, but – in the rest of the order; ellagic acid is present in Eucommiaceae but not in the rest of the order. *Eucommia* has polyisoprenes and gutta. It is less happily placed here than Moraceae, Ulmaceae, and Urticaceae.

EUCOMMIACEAE (Figure 34a,b).—Trees with laticiferous cells; xylem vessel perforation plates simple, some scalariform in primary xylem (Solereder); leaves alternate, simple, serrate, exstipulate; plants dioecious; perianth 0; ♂ inflorescence a few-flowered glomerule; flowers with 10 (4–12) stamens, the filaments very short, the anthers long, linear, basifixed, apically produced; pollen 3-colporoidate; ♀ flowers solitary, in the axil of a bract or bract-like leaf; pistil 1, the carpels 2, one aborting, the styles 2, stigmas decurrent ventrally; ovules 2, collateral, apical, unitegmic, crassinucellar or subtenuinucellar, anatropous; fruit a samara; embryo straight, as long as the endosperm; cotyledons thin, 1.5 times wider than the radicle, 0.7 the length of the embryo; endosperm copious.

Composition: 1 genus, 1 species.

Distribution: Montane forests of temperate China.

BARBEYACEAE (Figure 34c,d).—Trees; xylem vessel perforation plates simple, phloem sieve plates compound; leaves opposite, simple, entire, exstipulate; plants dioecious; inflorescence a short cyme; ♂ flower calyx of 3–4 nearly free, valvate sepals; petals 0; stamens 6–9 (10, 12), the filaments very short, anthers basifixed, twice as long as wide, the connective slightly produced apically; pollen 3-colpor(oid)ate; ♀ flower pistils 1–3, sometimes slightly connate laterally; sepals

3–4, accrescent; petals 0; ovary superior, style linear, the stigma plumose, decurrent all around, the ovule 1, subapical; fruit a nutlet; embryo straight, the cotyledons flattened, radicle short; endosperm 0.

Composition: 1 genus, 1 species.

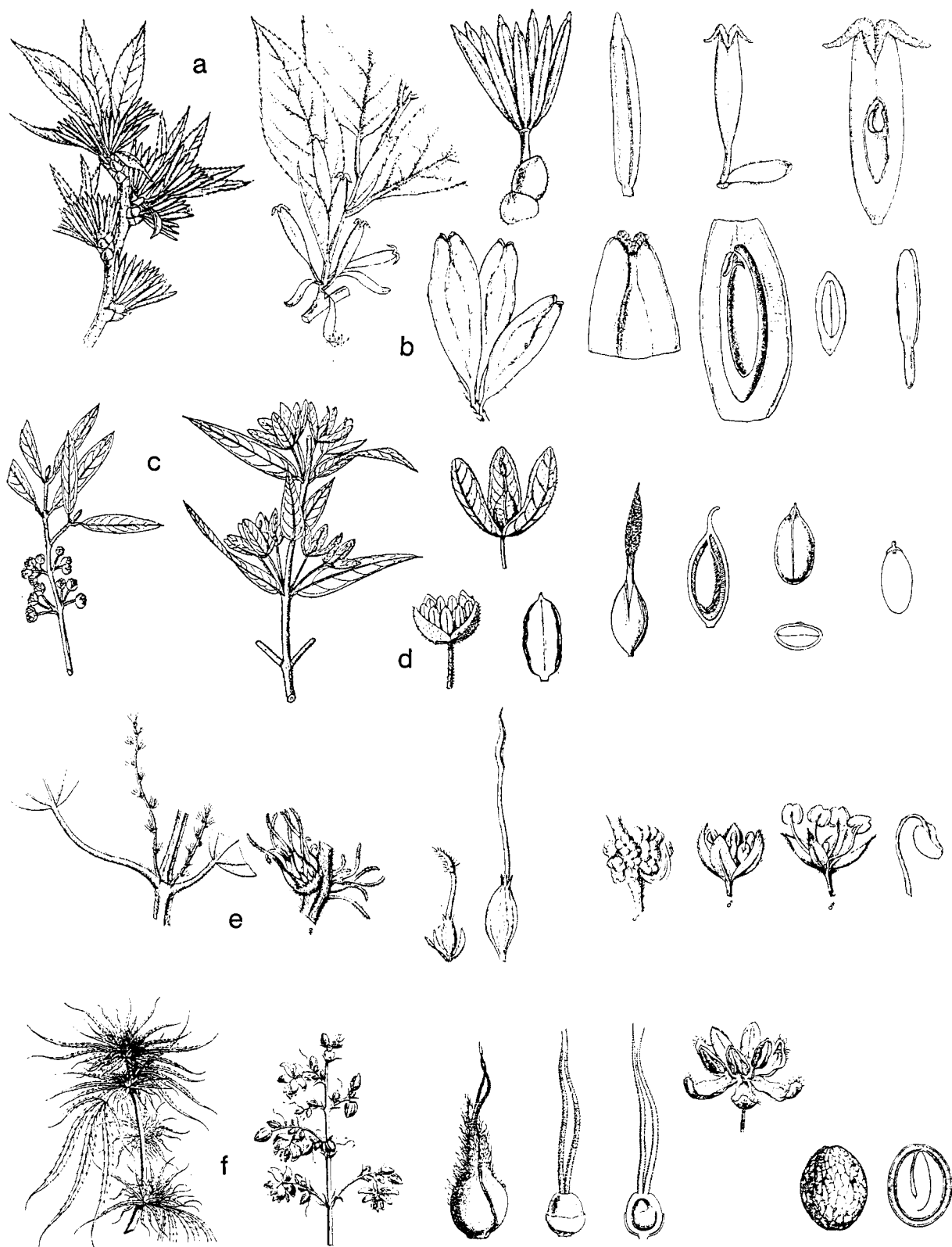
Distribution: Northeastern Africa, Arabia.

URTICACEAE (Figure 34e).—Herbs, shrubs, and soft-wooded trees, the stems often fibrous; xylem vessel perforation plates simple; laticiferous canals rarely present; sometimes possessing stinging hairs; leaves alternate or opposite, simple, usually serrate, cystoliths often abundant, usually stipulate; inflorescence axillary, cymose spikes or heads, the flowers minute; plants usually monoecious or dioecious, or rarely the flowers bisexual; calyx 4–5(0, 2, 3)-lobed or the sepals free, often accrescent; petals 0; stamens 4–5 (1–3), the filaments elongate, inflexed in bud; anthers dorsifixed, slightly longer than wide; pollen 3(2–15)-porate; pistil 1, the carpel 1, stigma often fimbriate, often sessile; ovary superior or inferior, the ovule 1, basal, bitegmic, crassinucellar, orthotropous or semi-anatropous; fruit an achene or drupelet; embryo straight, 0.9 to as long as the endosperm; cotyledons moderately thick, 2.3–4.0 times wider than the radicle, 0.5–0.7 the length of the embryo; endosperm scanty, fleshy and oily.

Composition: 45 genera, ~800 species.

Distribution: Worldwide; more genera and species in tropical than temperate regions.

CANNABACEAE (Figure 34f).—Fibrous herbs, sometimes scandent; laticiferous or resiniferous canals present; xylem vessel perforation plates simple; leaves alternate or opposite, simple, serrate, sometimes palmately lobed, cystoliths present, stipulate; plants dioecious; inflorescence axillary, ♂ cymose panicle, ♀ cymose spike; calyx 5-partite (♂) or entire (♀); petals 0; stamens 5, short; anthers erect in bud; pollen 3-porate; pistil 1, the carpels 2, styles 2, filiform, stigmas decurrent; ovary superior, unilocular, the ovule solitary, bitegmic, crassinucellar, anatropous, inserted midway in the locule; fruit an achene; embryo arcuate or coiled, 1.7–2.3 times longer than the



endosperm; cotyledons moderately thick, 2–3 times wider than the radicle, 0.5–0.7 the length of the embryo; endosperm scanty or moderate, fleshy.

Composition: 2 genera, 3 species.

Distribution: Temperate and subtropical Northern Hemisphere.

MORACEAE (Figure 35a–c).—Trees and shrubs, rarely herbs, laticiferous; xylem vessel perforation plates simple; leaves alternate, rarely opposite, simple, serrate or entire, sometimes lobed, cystoliths often present, stipulate; plants monoecious or dioecious; inflorescences axillary, cymose or dense spikes, umbel or head, the flowers minute; sepals 4 (8–0), free or connate, sometimes fleshy in fruit; petals 0; stamens usually 4 (1–2), the filaments inflexed or straight in bud; anthers dorsifixed, as long as wide; pollen 2–4(–5)-porate; pistil 1, the carpels 2, one frequently aborting, the styles 2 (1), filiform, stigmas short or decurrent; ovary superior or inferior, unilocular, the ovule 1, usually apical, rarely basal, bitegmic, crassinucellar, anatropous, semianatropous or campylotropous; fruit achenes, nutlets or drupelets, often a multiple fruit, the receptacle sometimes fleshy; embryo often arcuate; 1.5–1.7 times longer than the endosperm; cotyledons thin or moderately thick, 2–2.7 times wider than the radicle, 0.5–0.6 the length of the embryo; endosperm moderate or scanty, rarely 0, fleshy.

Composition: ~55 genera, ~1,400 species.

Distribution: Mainly pantropical and -subtropical, few temperate.

FIGURE 34.—EUCOMMIACEAE: *a*, *Eucommia ulmoides* ♂ flowering twig, ♀ flowering twig, ♂ flower and bracts, anther, ♀ flower and bract, l.s. of ♀ flower; *b*, fruits, upper part of fruit, l.s. of fruit, c.s. of seed, embryo (after Oliver). BARBEYACEAE: *c*, *Barbeya oleoides* ♂ flowering twig, ♀ flowering twig, ♀ flower; *d*, ♂ flower, stamen, pistil, l.s. of fruit, seed and c.s. of same, embryo (after Hutchinson, 1973; Penzig). URTICACEAE: *e*, *Boehmeria arguta* ♀ inflorescence, part of same enlarged, ♀ flower with bracts, ♀ flower, *B. caudata* part of ♂ inflorescence, ♂ bud, ♂ flower, stamen (after Martius, 1840–1906). CANNABACEAE: *f*, *Cannabis sativa* ♀ flowering twig, ♂ inflorescence, ♀ flower enclosed in its bract, ♀ flower, l.s. of same, ♂ flower, fruit, l.s. of same (after Baillon, 1866–1895).

ULMACEAE (Figure 35d).—Trees and shrubs, not laticiferous; xylem vessel perforation plates simple, rarely also scalariform, with 1–6 bars (*Planera*); leaves alternate, rarely opposite, often asymmetrical, 2-ranked, serrate or entire, cystoliths present in a few species, stipulate; inflorescence axillary cymose fascicles or the ♀ flower solitary; flowers bisexual or the plants monoecious; sepals 4–5 (3–8), free or connate; petals 0; stamens 4–8 (10–16) erect in bud; filaments hypogynous or adnate to the base of the perianth, longer than the anthers, the latter slightly longer than wide, the connective rarely apically produced; pollen 2–5(–6)-porate or colpate; pistil 1, the carpels 2, the styles 2 (1), the stigma decurrent ventrally, rarely bi- or trifid apically; ovary superior, the locules 1 (–2), ovule 1, subapical, bitegmic, usually crassinucellar, anatropous or semi-anatropous; fruit a samara or subdrupaceous nutlet; embryo straight, arcuate or folded, 2.0–2.5 times longer than the endosperm; cotyledons thin or moderately thick, 1.5–4.7 times wider than the radicle, 0.6–0.8 the length of the embryo, the radicle sometimes invested; endosperm moderate to 0.

Composition: 15 genera, ~200 species.

Distribution: Pantemperate and -tropical but generally absent from deserts and the Amazon basin.

FABALES

Trees, shrubs, and herbs, sometimes lianas; xylem vessel perforation plates simple; leaves alternate, very rarely opposite, usually compound, rarely with tendrils or reduced to phyllodes, the margin usually entire, sometimes serrate, rarely lobed, stipulate, rarely exstipulate; inflorescence usually racemose, a raceme, spike, head, or panicle; flowers small to large, bisexual or rarely unisexual, the parts hypogynous to perigynous, perianth actinomorphic to zygomorphic; sepals 5 (3–6, 0), free or connate; petals 5 (–0), free or connate; stamens 1 to ~500, often 10, the filaments free or variously connate, the anthers basifixed or dorsifixed; pollen 3 (–6)-colpate or -colporate, or 2–4-porate; pistils 1,

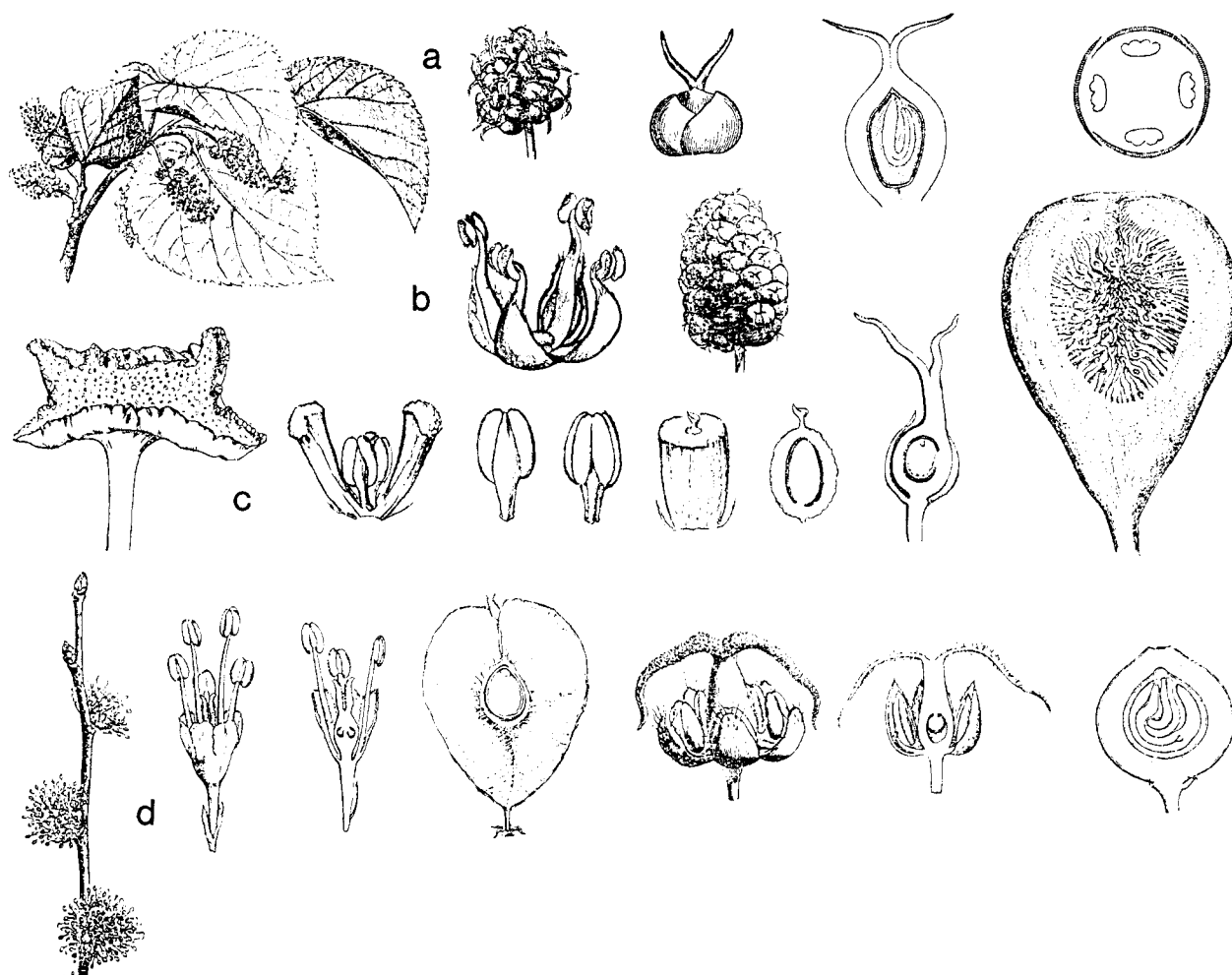


FIGURE 35.—MORACEAE: *a*, *Morus alba* ♂ flowering twig, ♂ inflorescence, *Morus* sp. ♀ flower, l.s. of fruit, *Sorocea* sp. diagram of ♂ flower; *b*, *Morus alba* ♂ flower, *M. nigra* multiple fruit; *c*, *Dorstenia* sp. inflorescence, *Cecropia adenopus* ♂ flower, views of stamen, *C. pachystachya* ♀ flower, l.s. of fruit, *Ficus carica* l.s. of ♀ flower, l.s. of multiple fruit (after Baillon, 1866–1895; Le Maout and Decaisne 1873; Martius, 1840–1906). ULMACEAE: *d*, *Ulmus campestris* inflorescences, flower, l.s. of same, l.s. of fruit showing seed and embryo, *Celtis australis* flower, l.s. of same, l.s. of fruit showing embryo (after Baillon).

very rarely 2–15, sessile or stipitate, unicarpellate, the style elongate or short, stigma apical or subapical; ovules 1–21 in 2 ventral rows; fruit usually a legume, sometimes samaroid, rarely a follicle, somewhat baccate, a drupe or loment; embryo large, straight or bent; endosperm moderate to absent.

Distribution: Cosmopolitan, most abundant in the tropics and subtropics.

Chemistry: Fabales have quite a few alkaloids, a greater variety than the Rosales. Quinalizidines are overwhelmingly commonest in legumes, but also occur in Ranunculales, Nymphaeales, Magnoliales, Laurales, Papaveraceae, and other taxa. Erythrine alkaloids occur in *Erythrina* and *Cocculus*. Fabales and Rosaceae are highly cyanogenic.

CAESALPINIACEAE (Figure 36*a–e*).—Trees,

shrubs, rarely lianas or herbs, rarely with 1–2 tendrils derived from twigs (*Bauhinia* spp.); xylem vessel perforation plates simple; leaves alternate, very rarely opposite, usually paripinnately, sometimes bipinnately compound, rarely simple, very rarely a phyllode, the margins almost always entire, rarely lobed or serrate, stipulate; inflorescence a raceme, spike, or rarely cyme; flowers bisexual or rarely the plants polygamous or dioecious (*Gymnocladus*), subactinomorphic to zygomorphic, the parts hypogynous to perigynous; sepals 5 (6, 0), free or rarely completely connate, imbricate or rarely valvate; petals 5–0, imbricate, the adaxial one internal; stamens 10 (1–30⁺), the filaments free or variously connate, staminodes present or absent; anther basifixed or dorsifixed, rarely dimorphic (*Maldenhauera*), dehiscent longitudinally or by terminal pores; pollen 3-colpate, 3-colporate, 3–6-colporoidate; disk sometimes present; pistil 1, very rarely 2–3 in *Swartzia*, sessile or stipitate, the carpel 1, style elongated, stigma apical or subapical, ovules 2–21 in 2 rows along the ventral suture, bitegmic, crassinucellar, anatropous or campylotropous, the funicles often long; fruit usually a legume, rarely a follicle, samara or drupe; seeds sometimes arillate, generally without areoles, rarely winged (*Melanoxylon*), the hilum apical or subapical; embryo 0.9 to as long as the endosperm, straight, or rarely folded, the radicle sometimes invested, the cotyledons thin or moderately thick, 2–7 times as wide as the radicle, 0.7–0.8 the length of the embryo; endosperm moderate, scanty or rarely absent, hard and glassy.

Composition: ~200 genera, ~2800 species.

Distribution: Pantropical and -subtropical, relatively few pantemperate.

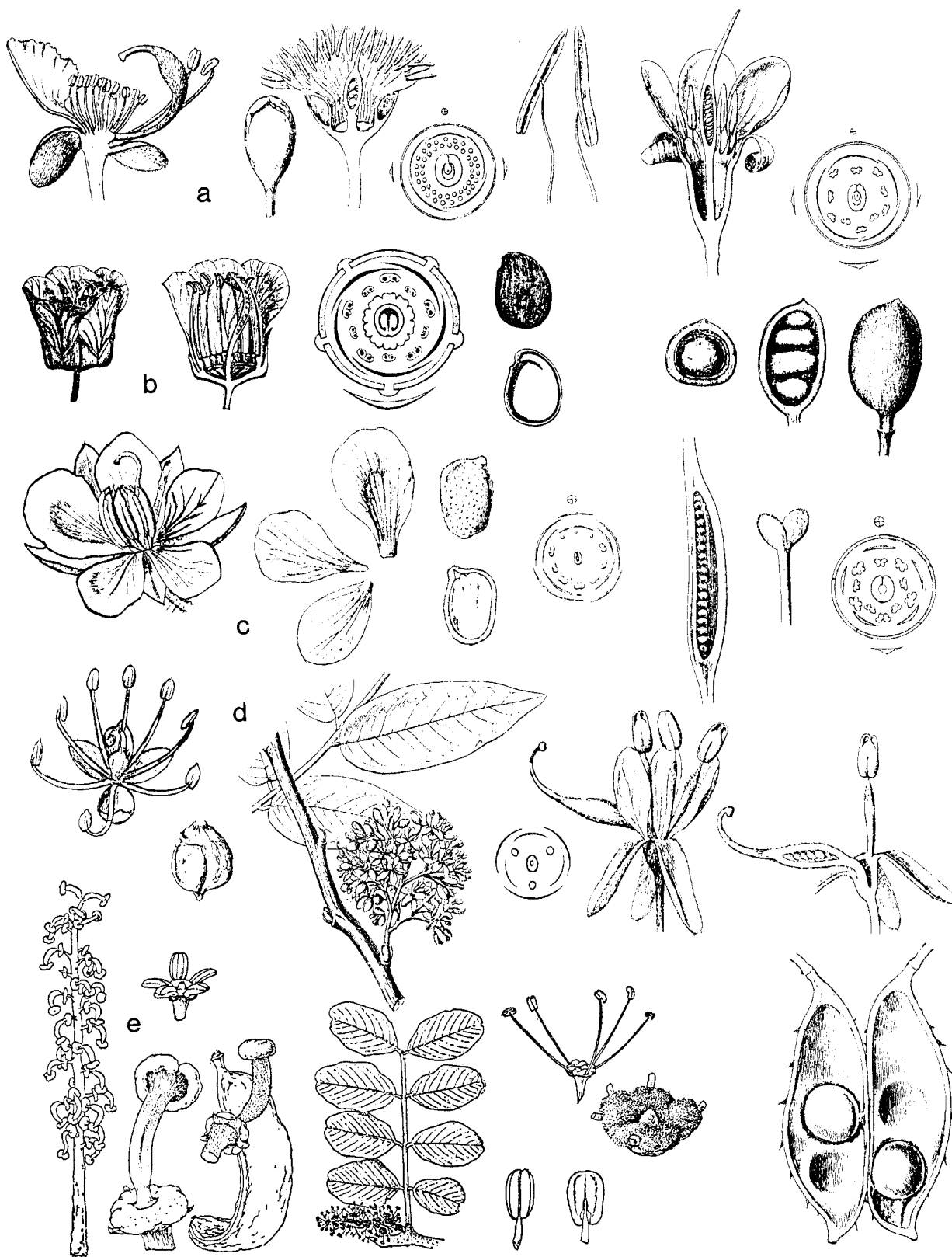
FABACEAE (Figure 37a–e).—Herbs, shrubs, rarely trees or vines, latex very rarely present (*Galactia*); xylem vessel perforation plates simple; leaves alternate or very rarely opposite or whorled, usually once compound and then usually imparipinnate, sometimes ending in a tendril, rarely simple, the margins usually entire, sometimes serrate, stipulate, rarely exstipulate; inflorescence a raceme, panicle, or spike, rarely

a cyme or the flower solitary; flowers bisexual, zygomorphic, the parts hypogynous to slightly perigynous; sepals 5 (–4), connate part way; petals 5, very rarely 1 or 0, imbricate, the adaxial one exterior and enlarged (standard), 2 lateral (wings), and 2 lower interior usually connate by their inner margin into a keel; stamens generally 10, rarely 9 or 5, monadelphous or diadelphous usually 9 + 1, rarely (5)+(5) or (4 + 1)+(4 + 1), rarely free; anthers dorsifixed or basifixed, sometimes dimorphic, mostly dehiscent longitudinally, rarely by terminal pores (*Fissicalyx*); pollen 3(2–6)-colporate, 2–4-porate, 3-colporoidate; pistil 1, sessile or stipitate, the carpel 1, style elongated or short, stigma apical or subapical, ovules about 2–14, ventral, bitegmic, crassinucellar, anatropous, semi-anatropous, campylotropous or amphitropous, the funiculus short; fruit usually a legume or sometimes indehiscent and somewhat baccate, drupoid, samaroid or a loment, rarely with a secondary longitudinal septum; seeds without areoles, the hilum often large and elongated; embryo 1–2 times as long as the endosperm, bent or rarely straight and the radicle invested, the cotyledons moderately to markedly thick, 0.8–5.5 as wide as the radicle, 0.6–0.9 the length of the embryo; endosperm scanty or 0, sometimes moderate, usually hard and glassy, not starchy.

Composition: ~450 genera, ~10,000 species.

Distribution: Pantropical, -subtropical, and -temperate.

Mimosaceae (Figure 38a–d).—Trees and shrubs, sometimes lianas, very rarely herbs; xylem vessel perforation plates simple; leaves alternate, very rarely opposite (*Tetrapleura*), mostly bipinnately compound, rarely once pinnate, paripinnate, the leaflets entire, very rarely ending in a tendril (*Entada*), sometimes reduced to phyllodes, rarely the rachis winged, stipulate or rarely exstipulate (some *Acacia*); inflorescence a head, spike or raceme; flowers bisexual or rarely the plants monoecious (*Neptunia*, *Archidendron*), small, actinomorphic, the parts hypogynous or rarely perigynous (*Parkia*); sepals small, 5 (3–6, 0) partly connate, rarely free, valvate or very rarely imbricate (*Parkieae*); petals 5 (3–6), usu-



ally connate or very rarely free, valvate; stamens 4–500, usually monadelphous, sometimes free, usually long-exserted, staminodes rarely present (*Pentaclethra*); anthers small, dehiscing longitudinally, often with an apical gland; pollen monads, tetrads, and polyads (to 32 cells), 3-colporate, rarely 3-porate; pistil 1 (–15), sessile or stipitate, the style elongated, stigma apical, the ovules several to 1, ventral, bitegmic, crassinucellar, anatropous or semianatropous, the funicle often long; fruit a legume or indehiscent with sweet pulp, rarely a loment leaving a replum; seeds \pm flattened, with an areole on each side (i.e., a line demarcating a central area), sometimes arillate or the testa fleshy, rarely winged, the hilum apical or subapical, \pm punctiform; embryo straight 0.8 to as long as the endosperm, the radicle invested; cotyledons thin or moderately to markedly thick, 2.3–5.0 times wider than the radicle, 0.7–0.8 the length of the embryo; endosperm moderate, scanty or 0, hard and glassy.

Composition: ~50 genera, ~2400 species.

Distribution: Pantropical and -subtropical, few pantemperate.

PAPAVERALES

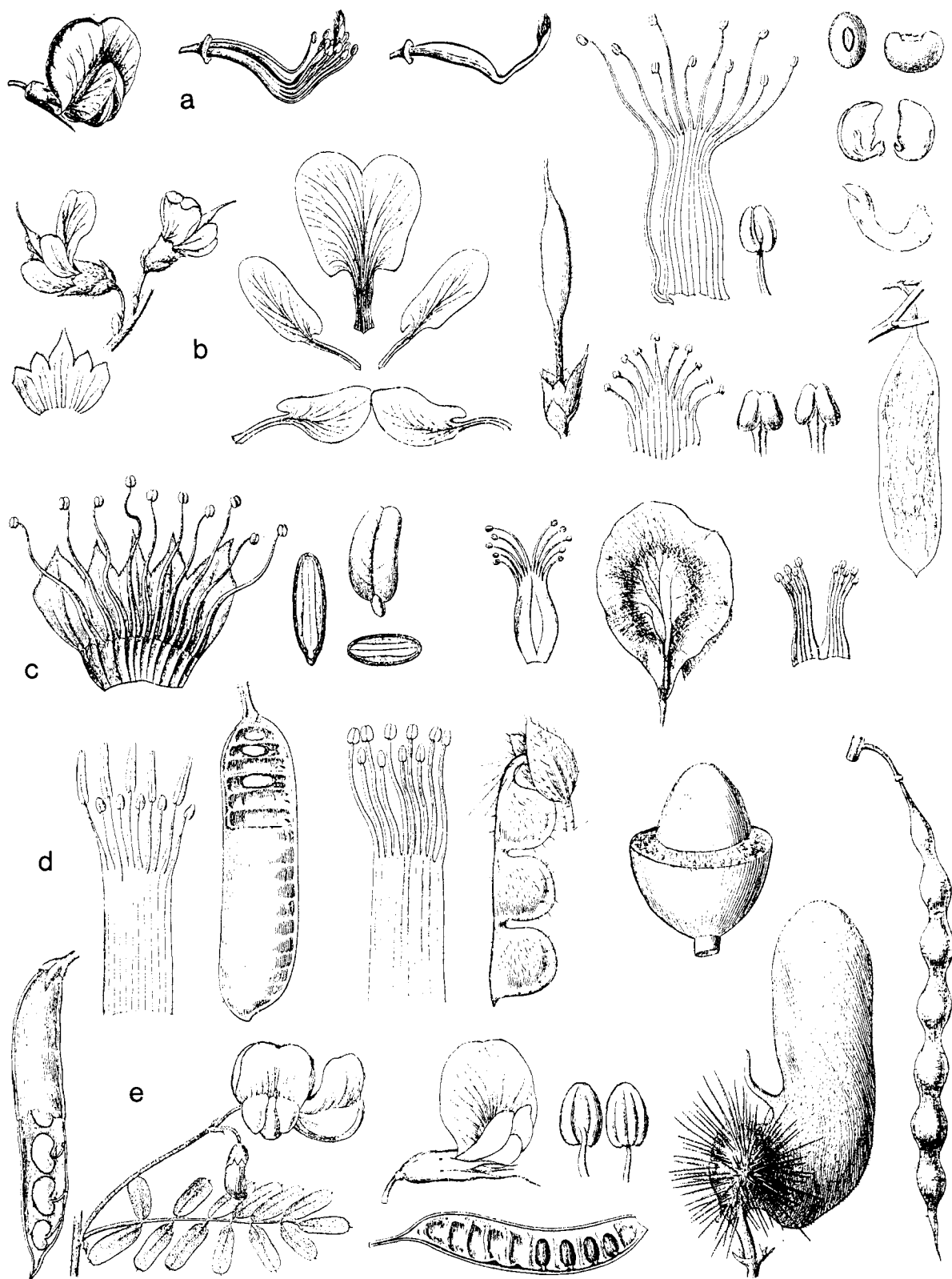
Herbs and shrubs, rarely lianas or small trees, sometimes laticiferous; xylem vessel perforation plates simple or very rarely scalariform; leaves

alternate, rarely opposite, simple, entire or lobed to dissected, sometimes compound with entire leaflets, usually exstipulate; flowers actinomorphic or zygomorphic, bisexual or rarely unisexual, the parts hypogynous to perigynous; sepals 2–5 (–9), usually free, rarely connate, sometimes biseriate; petals 2–12 (0, 14) in 1–3 whorls, 2–3-merous, free or rarely connate; stamens 1 to ~100, usually free, very rarely connate, the anthers basifixed or dorsifixed; pollen mostly 3 (2–9)-colpate or colpate, sometimes rupate, rugate, forate or nonaperturate; glandular disk often present, of separate parts or lining an hypanthium; pistil 1, sometimes stipitate, the carpels 2–20, rarely free in Resedaceae, the style usually 1, rarely several and the stigmas apical, or the stigmas sessile and linear or apical; ovary superior, unilocular or secondarily bilocular by the placentas meeting or by a secondary septum, the ovules usually numerous, rarely only 1, usually parietal; fruit usually a capsule, silique, or berry, rarely a nutlet or drupe or transversely dehiscent into joints; embryo minute to long, linear, arcuate or folded; endosperm copious, scanty or absent.

Distribution: Cosmopolitan, centered in the north temperate zone, often in dry habitats, more rarely in wet forests.

Chemistry: Myrosin-cells containing mustard-oil glucosides are present except in Papaveraceae and Tovariaceae(?). They are present in *Bretschneidera*. Mustard-oil glucosides also occur in Tropaeolaceae, Limnanthaceae, Zygophyllaceae, and rarely in Euphorbiaceae. Alkaloids are an important feature of Papaveraceae but the other families lack most of them; aporphine alkaloids are numerous in Papaveraceae. Protoberberines are most frequent in Papaveraceae, also in Magnoliales, Laurales, Ranunculales, *Nandina*, and *Aristolochia*. Phthalene-isoquinoline occurs mostly in Papaveraceae, Ranunculales, and *Brassica*, but also in various other unrelated groups. Cistaceae has monoterpenes, sesquiterpenes, and diterpenes; the HCl/Methanol Test is strongly +. Bixaceae and Cochlospermaceae have triterpenoid saponins and/or sapogenins. These are

FIGURE 36.—CAESALPINIACEAE: *a*, *Swartzia microcarpa* flower, *Aldina latifolia* bud, l.s. of flower (the filaments connate), floral diagram, views of anther, *Exostyles venusta* l.s. of flower, floral diagram; *b*, *Cadia varia* flower, l.s. of same, floral diagram, seed and l.s. of same, *Zollernia ilicifolia* c.s. and l.s. of fruit, fruit; *c*, *Cassia setosa* flower, petals, seed and l.s. of same, *C. multijuga* floral diagram, *Bauhinia forficata* l.s. of ovary, stigma, floral diagram; *d*, *Copaifera martii* flower, *C. langsdorfii* arillate seed, *Apuleia praecox* flowering twig, floral diagram, flower, l.s. of same; *e*, *Ceratonia siliqua* ♀ inflorescence, young ♀ flower with staminodes, ♀ flower showing large stigma and disk, ♀ flower from below and fruit, ♂ flowering twig, ♂ flower, views of anther, disk with pistillode in center, *Caesalpinia echinata* dehiscent fruit (after Martius, 1840–1906; Baillon, 1866–1895; Johnson).



not characteristic of the Violales. The alkaloids in Fabales and Papaverales seem to be different in many cases, rarely the same.

PAPAVERACEAE (Figure 39a-e).—Herbs, shrubs, or small trees, often with white, yellow, or red sap, the stem bundles in some species of *Papaver* in concentric zones and tending to be scattered, recalling Ranunculaceae; xylem vessel perforation plates simple, diameter of vessels very small, the vessels sometimes tracheid-like (*Romneya*); leaves simple, alternate, those just below the flowers rarely opposite or whorled, entire, lobed, or much divided, exstipulate; flowers mostly solitary, sometimes in dichasia, racemes, or panicles, essentially actinomorphic, bisexual, the parts hypogynous or rarely perigynous; sepals 2–3, caducous, free or rarely connate and calyprate; petals 4–12 (0) in 2 (3) whorls, free, often 2-merous, sometimes 3-merous, often crumpled in bud, without nectaries; stamens usually numerous (~6–85), the filaments filiform, anthers basifixed; pollen mostly 3 (2–9)-colpate, also rupate, rugate, forate, or non-aperturate; pistil 1, the carpels 2–20, the style short or absent, rarely several, the stigmas usually linear, sometimes apical; ovary superior, unilocular or several locular by the placentas meeting at the center of the ovary, or rarely bilocular by a secondary septum; ovules usually numerous, parietal, rarely 1 and basal, bitegmic, crassinucellar, anatropous or subcampylotropous; fruit a

capsule dehiscing by valves or pores, rarely a silique, rarely the carpels separate and torulose in fruit; seeds often arillate; embryo minute or long and linear, straight or arcuate, 0.07–0.9 the length of the endosperm; cotyledons hardly differentiated to nearly 0.5 the length of the embryo and as wide as the radicle; endosperm copious, fleshy and oily.

Composition: 26 genera, ~200 species.

Distribution: Temperate and subtropical North America and Eurasia; few in eastern Australia and South Africa.

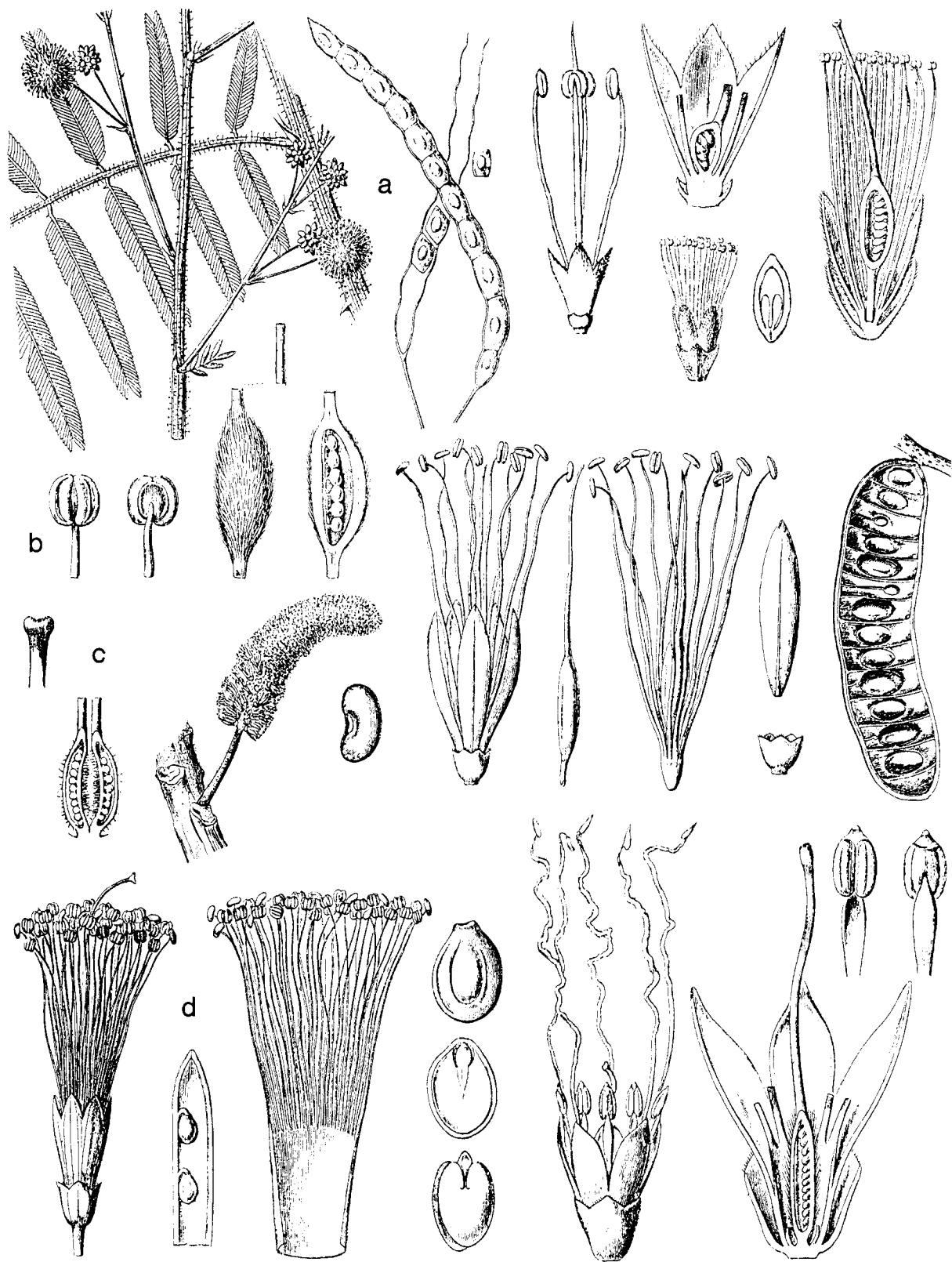
FUMARIACEAE (Figure 40a).—Herbs, sometimes scandent, with watery sap; xylem vessel perforation plates simple; leaves simple, radical or ascending the stem, alternate or rarely subopposite, usually much divided, exstipulate; inflorescence usually a raceme; flowers bisexual, zygomorphic, the parts hypogynous; sepals 2, small, caducous; petals 4, biseriate, \pm connivent, 1 or 2 outer ones often saccate or spurred, the 2 inner narrower and sometimes apically connate, or all the petals connate in a tube (*Adlumia*); stamens 4 free and opposite the petals, or 6 connate in 2 bundles, with 1 or 2 nectaries at the base, sometimes extending into the spur; filaments elongated, the anthers small; pollen 2–4-colpate, 3-colp(oroïd)ate, occasionally 4-rupate, 6- or 12-rugate, 6–12-forate; pistil 1, the carpels 2, the style 1, slender, stigmas 2, apical; ovary unilocular, placentas 2, the ovules 1 to many, parietal, bitegmic, crassinucellar, anatropous or campylotropous; fruit often an elongated capsule, sometimes transversely septate and breaking into 1-seeded indehiscent segments, or a bivalved silique, sometimes a nutlet; seeds shiny, usually arillate; embryo small, straight, linear, 0.1–0.2 the length of the endosperm; cotyledons 0.2–0.4 the length of the embryo, twice as wide as the radicle; endosperm copious, fleshy.

Composition: 16 genera, 450 species.

Distribution: Temperate North America and Eurasia; few in the highlands of eastern Africa and in South Africa.

TOVARIACEAE (Figure 40b).—Herbs or shrubs with a strong odor; xylem vessel perforation

FIGURE 37.—FABACEAE: a, *Pisum sativum* flower, essential organs, pistil, *Vigna luteola* androecium laid open, anther, views of seed, views of embryo, plumule; b, *Dalbergia variabilis* calyx, flowers, petals, pistil and calyx, androecium, views of anther, fruit; c, *Bowdichia virgilioides* calyx laid open showing insertion of the stamens, l.s. and c.s. of seed, embryo, *Pterocarpus violaceus* androecium, fruit, *Machaerium aculeatum* androecium; d, *Harpalyce brasiliensis* androecium laid open, fruit with part removed to show the seeds, *Aeschynomene falcata* androecium laid open, fruit, *Andira anthelmintica* section of fruit showing the seed; e, *Isodesmia tomentosa* fruit with part removed to show the seeds, inflorescence in leaf axil, *Clitoria stipularis* flower, views of anther, 1 valve of fruit showing seeds, *Centrolobium robustum* fruit, *Sophora tomentosa* fruit (after Martius, 1840–1906, Baillon, 1866–1895).



plates simple; leaves trifoliolate, the leaflets entire, stipulate; inflorescence a terminal raceme; flowers bisexual, actinomorphic, the parts hypogynous; sepals 8 (7–9), deciduous; petals 8 (7–9); stamens 8 (7–9) oppositisealous, the filaments filiform, nectaries absent; anthers twice as long as wide, basifixed; pollen (2–)3-colporoidate; pistil 1, the carpels 6–8, stigma 6–8-lobed, subsessile; ovary 6–8-locular, the ovules numerous, parietal, bitegmic, crassinucellar, campylotropous; fruit a berry, the seeds minute, shiny; embryo linear, arcuate, 0.7 the length of the endosperm, the cotyledons 0.3 the length of the embryo; endosperm copious.

Composition: 1 genus, 2 species.

Distribution: Mexico to Andes of Peru; Jamaica.

CAPPARACEAE (Figure 41a–e).—Small trees, shrubs, or herbs, rarely lianas; xylem vessel perforation plates simple, small tracheid-like members sometimes numerous; leaves alternate or rarely opposite, simple or palmately 3–7-foliate, rarely reduced to scales 1 mm long (*Koeberlinia*), the stipules represented by thorns or glands; inflorescence usually a raceme; flowers actinomorphic or zygomorphic, mostly bisexual, the plants rarely monoecious or dioecious, the parts hypogynous; sepals 4 (–8) in 2 whorls, free or partly to wholly connate and calyptrate; petals 4 (–14, or 0), sometimes connate; disk sometimes present between the perianth and stamens, often thicker to one side; stamens 100 + to 1, dimorphic in *Cladostemon*, the filaments filiform, rarely widened in the middle (*Koeberlinia*), the anthers oblong, dorsifixed; an androphore some-

times present; pollen 3(2–4)-colporate (–colporoidate); pistil 1, the carpels 2 (–12) in 1 or 2 whorls, the style filiform or absent, the stigma bilobed or capitate, apical; ovary usually stipitate, unilocular or sometimes with a secondary septum, the ovules many to few, parietal or very rarely axile, bitegmic, crassinucellar, campylotropous; fruit a berry, sometimes torulose, silique, apically dehiscing capsule, rarely a drupe or transversely locellate (*Maerua* spp.), or nutlets; seeds often reniform; embryo linear, arcuate, as long as the endosperm, the cotyledons 0.3–0.7 the length of the embryo; endosperm scanty, fleshy.

Composition: ~42 genera, ~900 species.

Distribution: Mostly in arid regions, mainly tropical and subtropical, few temperate; temperate North America to temperate South America; Japan to eastern Mediterranean region and south to South Africa and Australia.

PENTADIPLANDRACEAE (Figure 42a–b).—Large shrubs and climbers; xylem vessel perforation plates simple(?); leaves alternate, simple, entire, exstipulate; inflorescences axillary and terminal few-flowered racemes, rarely also umbels; plants polygamous; sepals 5, free, imbricate in bud; petals 5, free, cupular and connivent basally; stamens 9–13, the filaments free, filiform; anthers small, basifixed, the connective produced into an apical knob; pollen (2–)3-colpate; disk thick, cupular, external to the stamens; pistil 1, the carpels 5–4, the style 1, elongated, the stigmas 5–4; ovary superior, stipitate, 5–4-locular, the ovules several, in 2–3-series per locule, campylotropous, axile; fruit a berry, the seeds reniform, embryo curved, cotyledons short; endosperm 0 or very scanty.

Composition: 1 genus, 2 species.

Distribution: Tropical west Africa, in forest.

RESEDACEAE (Figure 42c–e).—Herbs or rarely shrubs with watery sap; xylem vessel perforation plates simple; leaves simple, alternate, entire or pinnately dissected, the stipules gland-like; inflorescence a raceme or spike; flowers bisexual or rarely the plants monoecious, usually zygomorphic, the parts hypogynous; sepals 2–8, sometimes basally connate; petals small, 2–8 (0),

FIGURE 38.—MIMOSACEAE: a, *Mimosa somnians* flowering twig, fruit entire and dehiscent, *M. vellosiana* flower, l.s. of same with part of the style and filaments cut off, *Acacia miersii* flower, c.s. of ovary, l.s. of flower; b, *M. somnians* views of anther, pistil, l.s. of ovary; c, *Affonsea bullata* stigma, l.s. of ovaries, *Stryphnodendron barbatimão* inflorescence, seed, flower, pistil, essential organs, petal and calyx, 1 valve of the fruit; d, *Calliandra longipes* flower, androecium laid open, *C. parviflora* part of fruit with 2 seeds, seed, l.s. of same, embryo, *Pentaclethra filamentosa* flower, l.s. of same with part of the filaments cut off, views of anther (after Martius, 1840–1906).

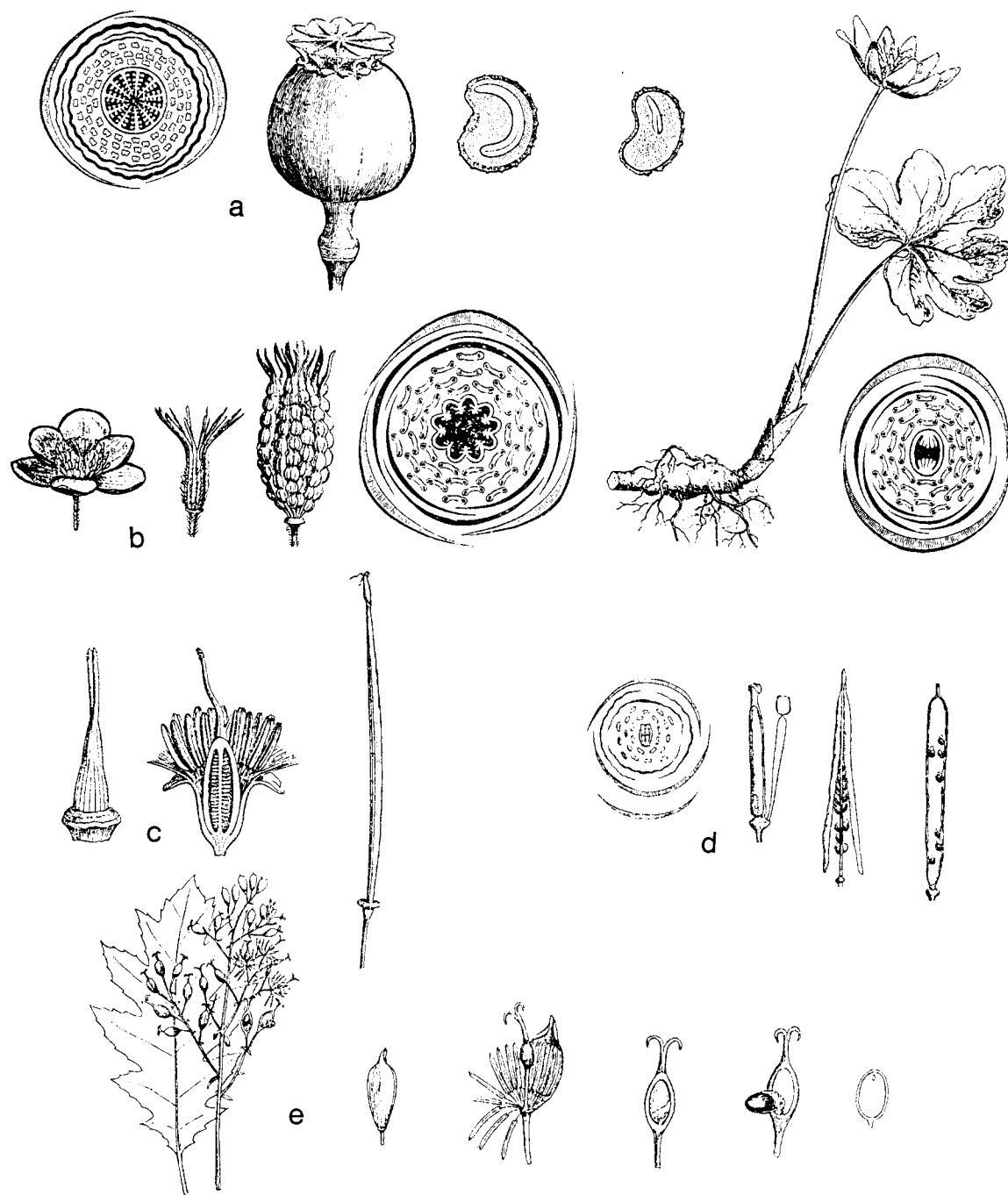


FIGURE 39.—PAPAVERACEAE: *a*, *Papaver somniferum* floral diagram, fruit, l.s. of seed, *Roemeria* sp. l.s. of seed; *b*, *Platystemon californicus* flower, pistil, fruit, floral diagram, *Sanguinaria canadensis* flowering plant, floral diagram; *c*, *Eschscholzia* sp. pistil, l.s. of flower with petals cut off, fruit; *d*, *Chelidonium majus* floral diagram, pistil and 1 stamen, dehiscent fruit, replum with some seeds still attached; *e*, *Bocconia frutescens* leaf, part of inflorescence-infructescence, flower bud, flower with 1 sepal removed, fruit with 1 valve gone, fruit with both valves gone, l.s. of seed showing the minute embryo (after Rendle, 1938; Baillon, 1866–1895; Le Maout and Decaisne, 1873).

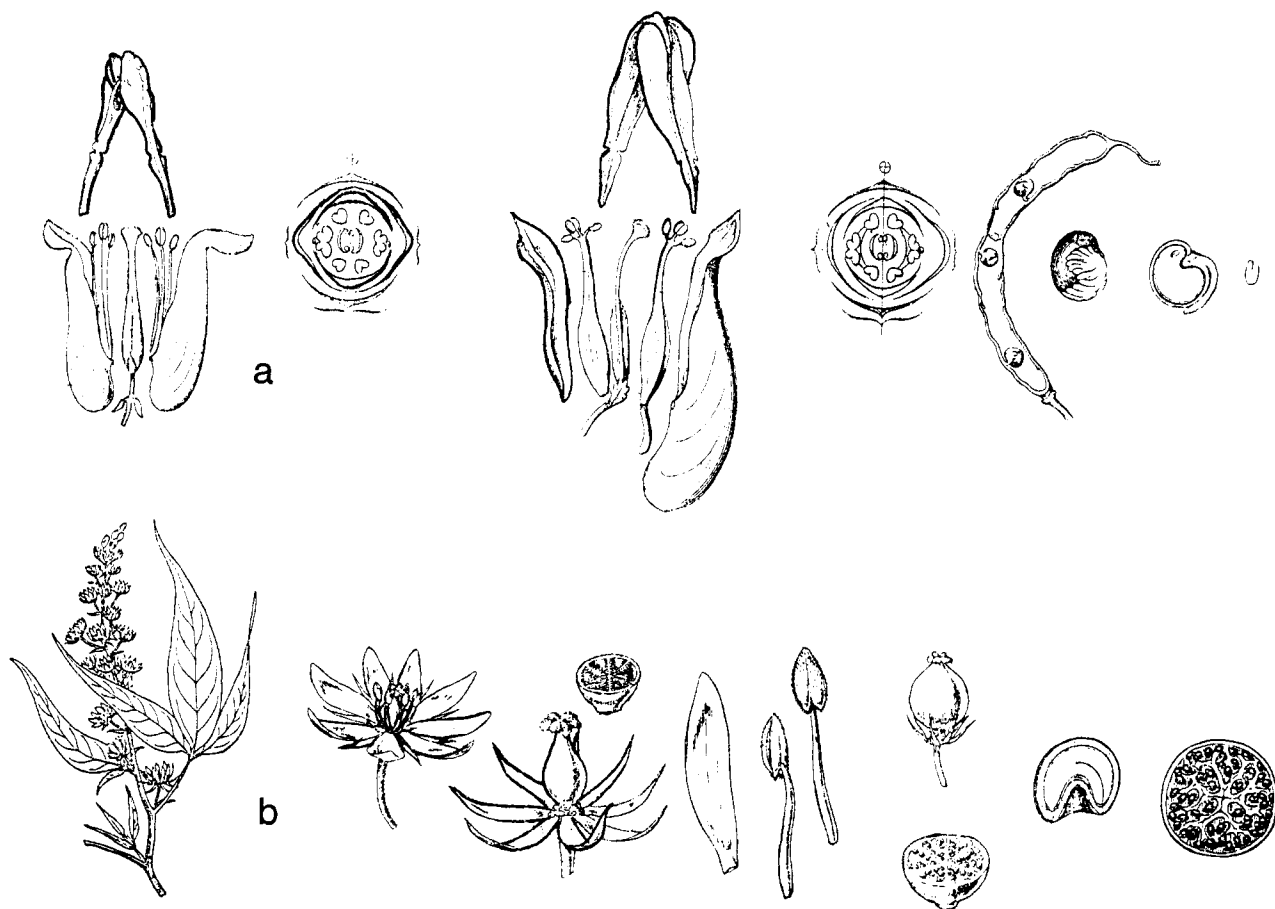


FIGURE 40.—FUMARIACEAE: *a*, *Dicentra canadensis* interior petals, rest of flower laid open, floral diagram, *Corydalis aurea* interior petals, rest of flower dissected, floral diagram, replum with seeds, seed, l.s. of same showing the minute embryo, embryo enlarged (after Gray). TAVARIACEAE: *b*, *Tovaria pendula* flowering shoot, flower, calyx and pistil, c.s. of ovary, petal, views of stamen, fruit and c.s. of same, l.s. of seed, *T. diffusa* c.s. of fruit (after Hooker and Hooker, 1837–1982; Pax).

often laciniate, rarely connate, sometimes with a scale at the base; disk often eccentric; androgynophore short; stamens 3–45, the filaments elongated; anthers as long as wide, dorsifixed?; pollen 3-colpate (-colporoidate); pistil 1, the carpels 2–7 rarely free; ovary unilocular, often open apically, the stigmas 2–7, sessile; ovules numerous to 1, bitegmic, crassinucellar or tenuinucellar, anatropous or campylotropous, parietal or basal; fruit a capsule open apically, berry, or separate fruitlets; seeds reniform, carunculate; embryo linear, arcuate, as long as the endosperm, the cotyledons 0.4–0.8 the length of the embryo and

as wide as the radicle; endosperm scanty, fleshy, or absent.

Composition: 6 genera, 70 species.

Distribution: Dry habitats, centered in the Mediterranean region; most of Europe to India; South Africa; southwestern United States.

BRASSICACEAE (Figure 43a–c).—Herbs, very rarely undershrubs, the sap watery; xylem vessel perforation plates simple; leaves alternate or rarely subopposite, opposite and alternate in *Chamira*, simple to compound, entire to variously cut, exstipulate; inflorescence usually a raceme or corymb; flowers bisexual, mostly actino-

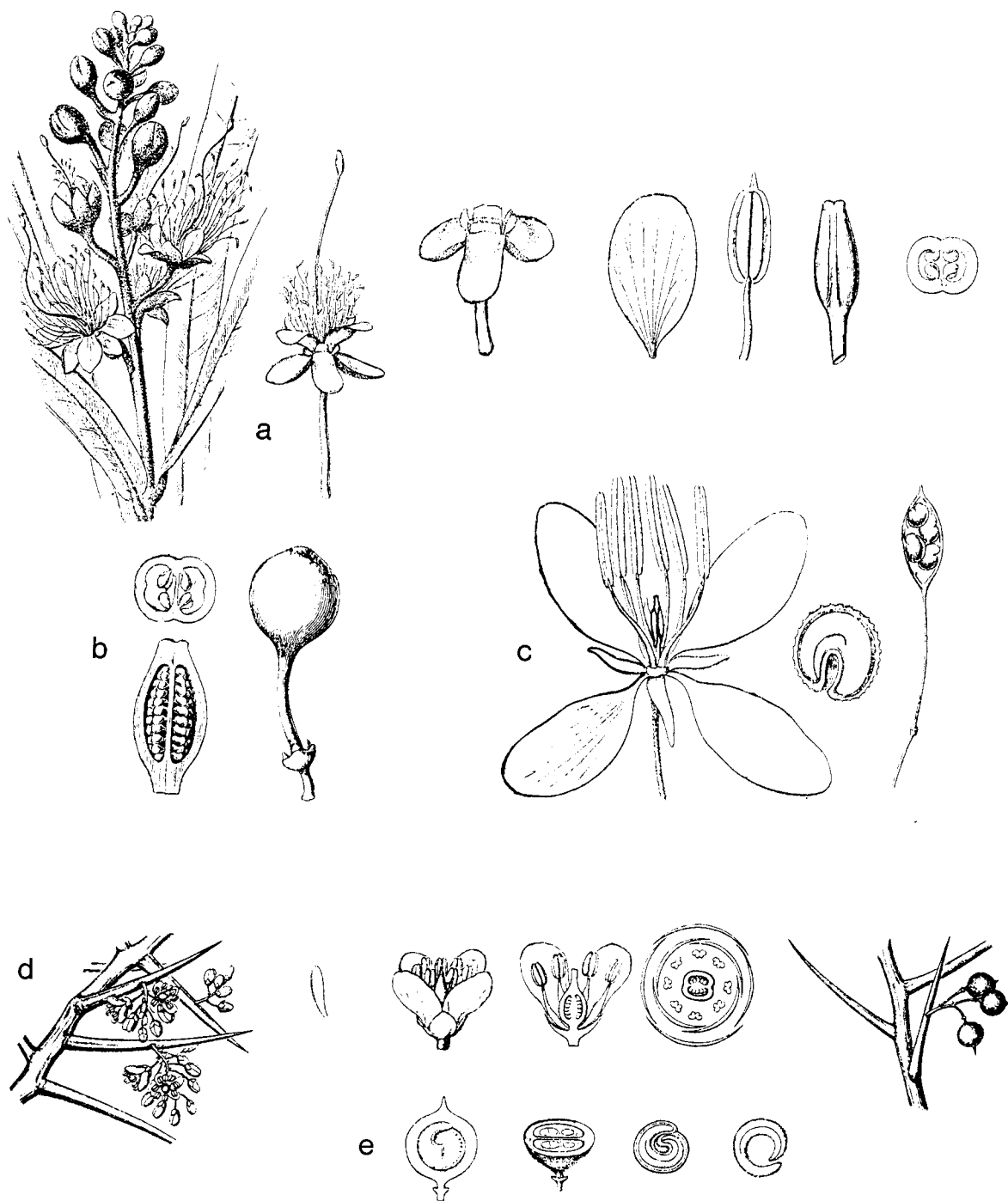


FIGURE 41.—CAPPARACEAE: *a*, *Capparis jacobinae* inflorescence, flower, calyx and disk segments, petal, stamen, pistil, c.s., of ovary; *b*, *C. avicennifolia* c.s. and l.s. of ovary, fruit; *c*, *Cleome rosea* bud laid open, l.s. of seed, *C. siliculifera* replum with seeds; *d*, *Koeberlinia spinosa* part of flowering twig, leaf (minute), flower, l.s. of same, floral diagram, part of fruiting twig; *e*, l.s. and c.s. of fruit, section of seed, embryo (after Martius, 1840–1906; Sargent).

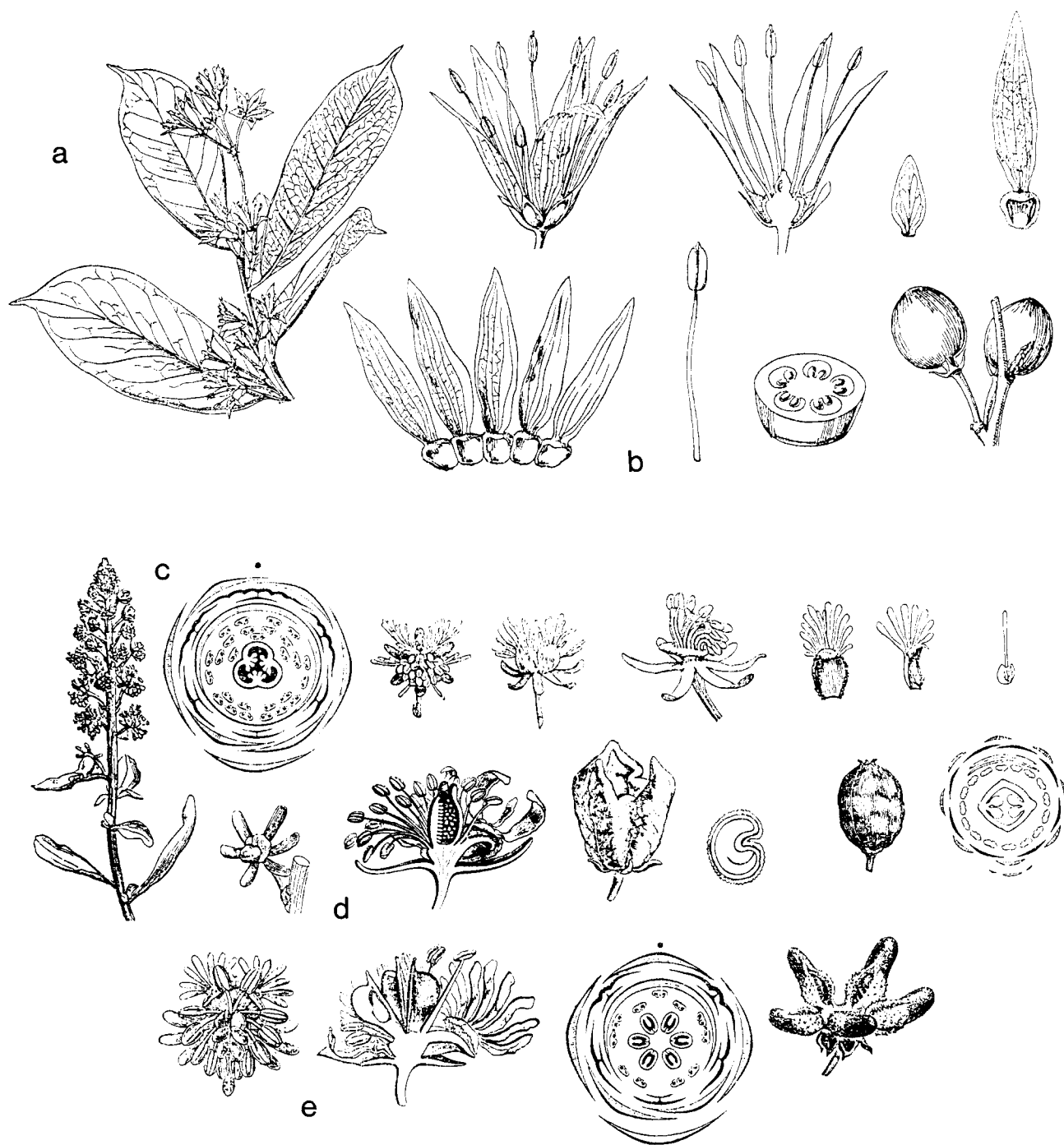


FIGURE 42.—PENTADIPLANDRACEAE: *a*, *Pentadiplandra brazzeana* flowering twig, ♂ flower, l.s. of same with pistillode, sepal, petal showing thickened basal portion; *b*, corolla showing connivent basal portions of petals, stamen, c.s. of ovary, fruits (after Hutchinson and Dalziel). RESEDACEAE: *c*, *Reseda odorata* flowering shoot, floral diagram, front view of flower, rear view, flower with petals removed, a posterior petal, a lateral petal, an anterior petal; *d*, calyx, disk and young pistil, *R. lutea* l.s. of flower, *R. odorata* fruit, l.s. of seed, *Ochradenus* sp. fleshy fruit, *Randonia africana* floral diagram; *e*, *Astrocarpus canescens* flower with 6 pistils, l.s. of flower, floral diagram, fruit (after Baillon, 1866–1895; Le Maout and Decaisne, 1873).

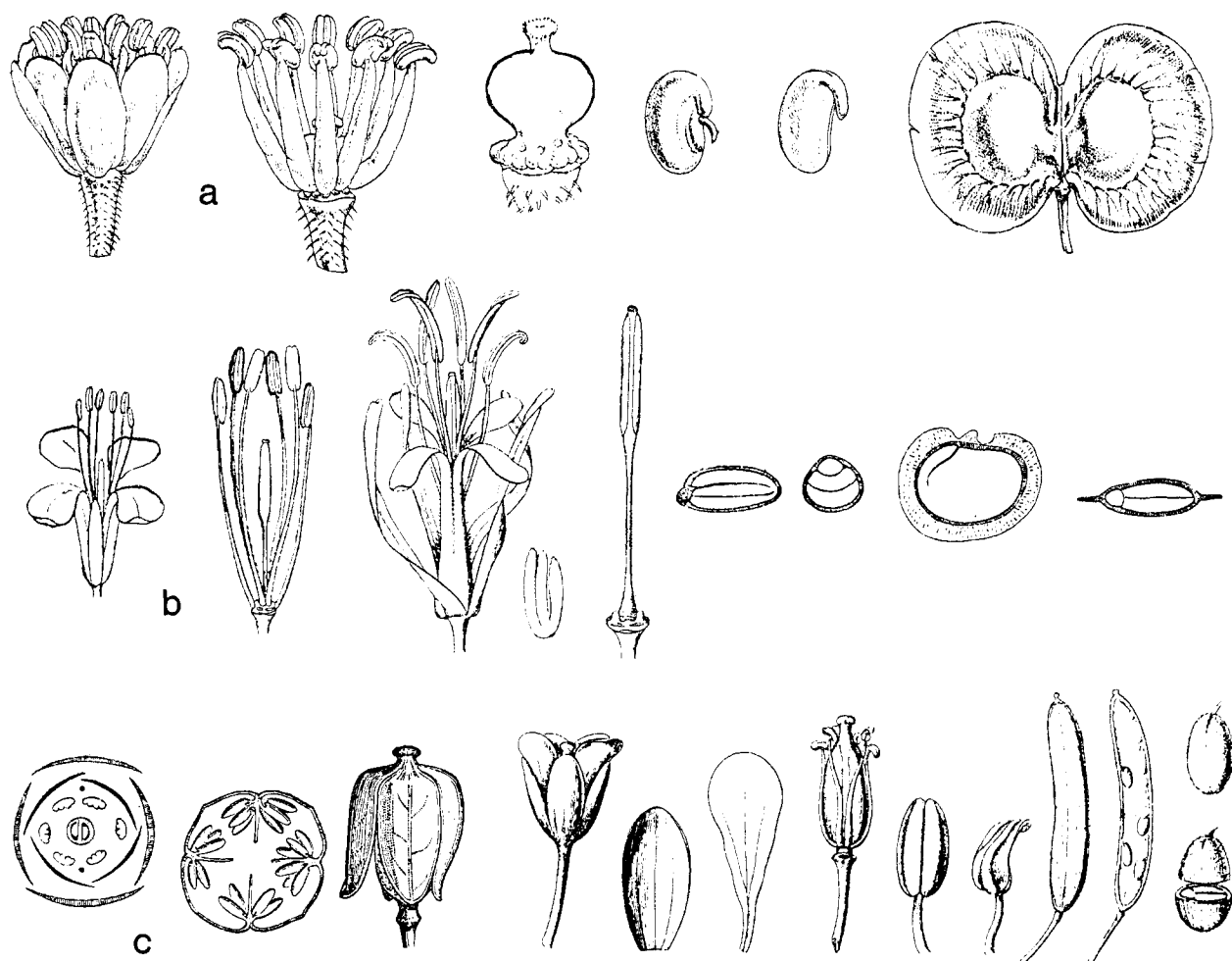


FIGURE 43.—BRASSICACEAE: *a*, *Megacarpaea polyandra* flower, same with perianth removed, pistil and receptacle, seed, embryo, fruit; *b*, *Warea cuneifolia* flower, essential organs, *Stanleya pinnatifida* flower, embryo, stipitate pistil, *Erysimum* sp. l.s. and c.s. of seed to show incumbent cotyledons, *Lunaria* sp. l.s. and c.s. of seed to show accumbent cotyledons; *c*, *Barbarea* sp. floral diagram, *Rorippa barbaraeifolia* c.s. of fruit, dehiscent fruit, *R. bonariensis* flower, sepal, petal, essential organs, views of anther, fruit, replum with seeds, seed and c.s. of same (after Hooker and Hooker, 1837–1882; Gray; Le Maout and Decaisne, 1873; Martius, 1840–1906).

morphic, the parts hypogynous; sepals 4, free, rarely connate (*Gamosepalum*), biseriate; petals 4 (0); stamens 6, tetradynamous, very rarely to 16 or 4, free or connate in pairs, the anthers dorsifixed; pollen usually (2–)3-colpate, 4-rupate, 6-rugate or nonaperturate; glands usually present on the receptacle, the nectar secreted into often

gibbous bases of the inner sepals; pistil 1, sessile or rarely stipitate, the carpels 2, very rarely 3 or 4 in some specimens, the style short, stigma(s) apical; ovary divided longitudinally by a secondary septum, rarely undivided or divided transversely, the ovules usually numerous, bitegmic, crassinucellar or tenuinucellar, campylotropous

or anatropous, parietal; fruit a silique or silicle, bivalved or rarely an indehiscent nutlet, or transversely dehiscent into joints; embryo coiled or folded, the cotyledons 2–10 times as wide as the radicle, thick or thin; 0.4–0.85 the length of the embryo; endosperm 0, very rarely very little present.

Composition: ~375 genera, ~3000 species.

Distribution: Cosmopolitan, centered in the north temperate zone, especially the Mediterranean region, central Asia, and western United States; rarer in the tropics.

MORINGACEAE (Figure 44a,b).—Trees exuding a gum resembling tragacanth from bark wounds; xylem vessel perforation plates simple; leaves alternate, 2–3 times pinnately compound, exstipulate or stipules represented by glands; inflorescence an axillary panicle; flowers honey-scented, bisexual, zygomorphic, the parts perigynous, the hypanthium short; sepals 5, petaloid; petals 5, differing in size; stamens 5, staminodes 5, inserted on the margin of a disk which lines the hypanthium, the filaments free; anthers 1.5 times longer than wide, finally unilocular, dorsifixed; pollen (2–)3-colporate; pistil 1, stipitate, the carpels 3 (–4), the style elongated, stigma apical; ovary unilocular, the ovules numerous, parietal, bitegmic, crassinucellar, anatropous; fruit a thick-walled, long, beaked, torulose, loculicidal capsule, 3 (–4)-valved; embryo straight, the cotyledons broad, thick, plano-convex, 0.9 the length of the embryo, radicle invested, plumule evident; endosperm 0.

Composition: 1 genus, 12 species.

Distribution: Arid habitats; Mediterranean region to western India; eastern and southwestern Africa, Madagascar.

BRETSCHNEIDERACEAE (Figure 44c).—Trees; xylem vessel perforation plates scalariform with about 20 bars; leaves alternate, compound, imparipinnate, the leaflets entire, exstipulate; inflorescence a terminal raceme; flowers bisexual, slightly zygomorphic, the parts perigynous; hy-

panthium present; sepals 5; petals 5, unequal; stamens 8, biseriate, the filaments filiform, anthers dorsifixed; pollen (2–)3-colpate; disk absent; pistil 1, sessile, the carpels 3, style 1, long, curved, the stigma apical; ovary 3-locular, the ovules 2 per locule, axile; fruit an obovate, thick-walled, 3-valved capsule, the seeds red; embryo straight, the cotyledons large, radicle very short; endosperm 0.

Composition: 1 genus, 2 species.

Distribution: Mountains of western China.

BATALES

The order is monotypic.

Chemistry: Batales have myrosin-cells. They have no betalains.

BATACEAE (Figure 45a,b).—Coastal fleshy subshrubs; xylem vessel perforation plates simple; leaves opposite, simple, entire, linear, subterete, exstipulate or stipules small; inflorescences axillary and terminal dense spikes or the ♀ flowers sometimes solitary, the plants dioecious or monoecious, the flowers minute; ♂ flower: sepals (bracts?) connate, the calyx bilabiate; petals 4, free, clawed; stamens 4 (2–5), free, the filaments elongated, anthers about twice as long as wide, dorsifixed, the connective sometimes apically produced; pollen 3–4-colporoidate (–ruporoidate); ♀ flower: sepals and petals 0; pistil 1, the carpels 2, stigma papillose, subsessile, apical, obscurely bilobed; ovary 4-locular, one of the 2 septa being secondary, the ovules 1 per locule, basal, the funicle elongated; fruits subdrupaceous and united into a fleshy mass, or 4 nutlets; embryo large, almost straight, oblanceolate; cotyledons oblong, plano-convex, slightly flattened, grading gradually into the radicle, twice as broad as the radicle, 0.6–0.8 the length of the embryo; endosperm 0.

Composition: 1 genus, 2 species.

Distribution: Coastal regions; warm temper-

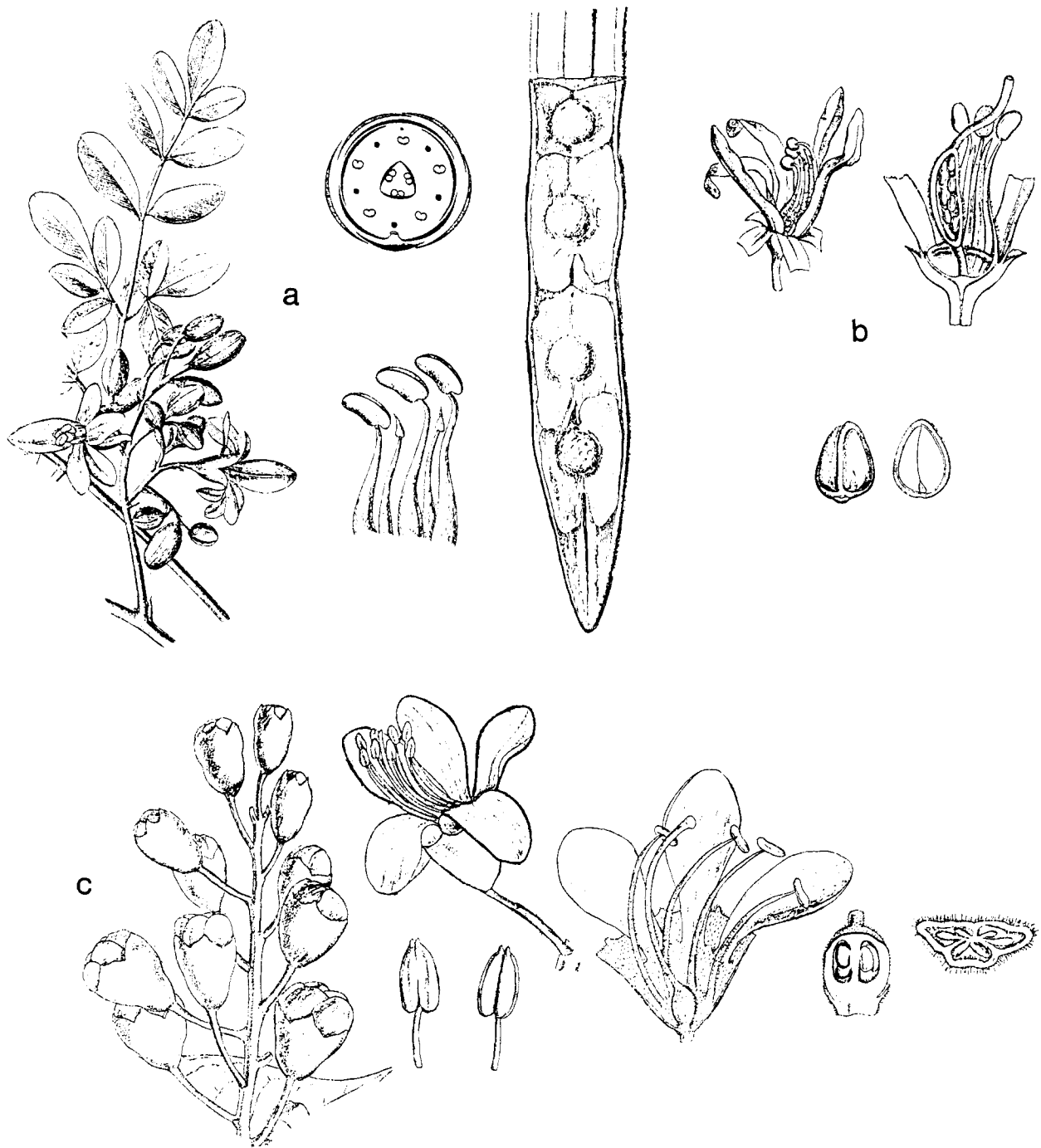


FIGURE 44.—MORINGACEAE: *a*, *Moringa oleifera* flowering twig, floral diagram and part of androecium, part of fruit cut open; *b*, *M. aptera* flower, l.s. of same, seed, l.s. of same (after Martius, 1840–1906; Le Maout and Decaisne, 1873). BRETSCHEIDERACEAE: *c*, *Bretschneidera sinensis* part of twig in bud, views of anther, flower, l.s. of same showing insertion of petals and stamens, l.s. and c.s. of ovary (after Hemsley).

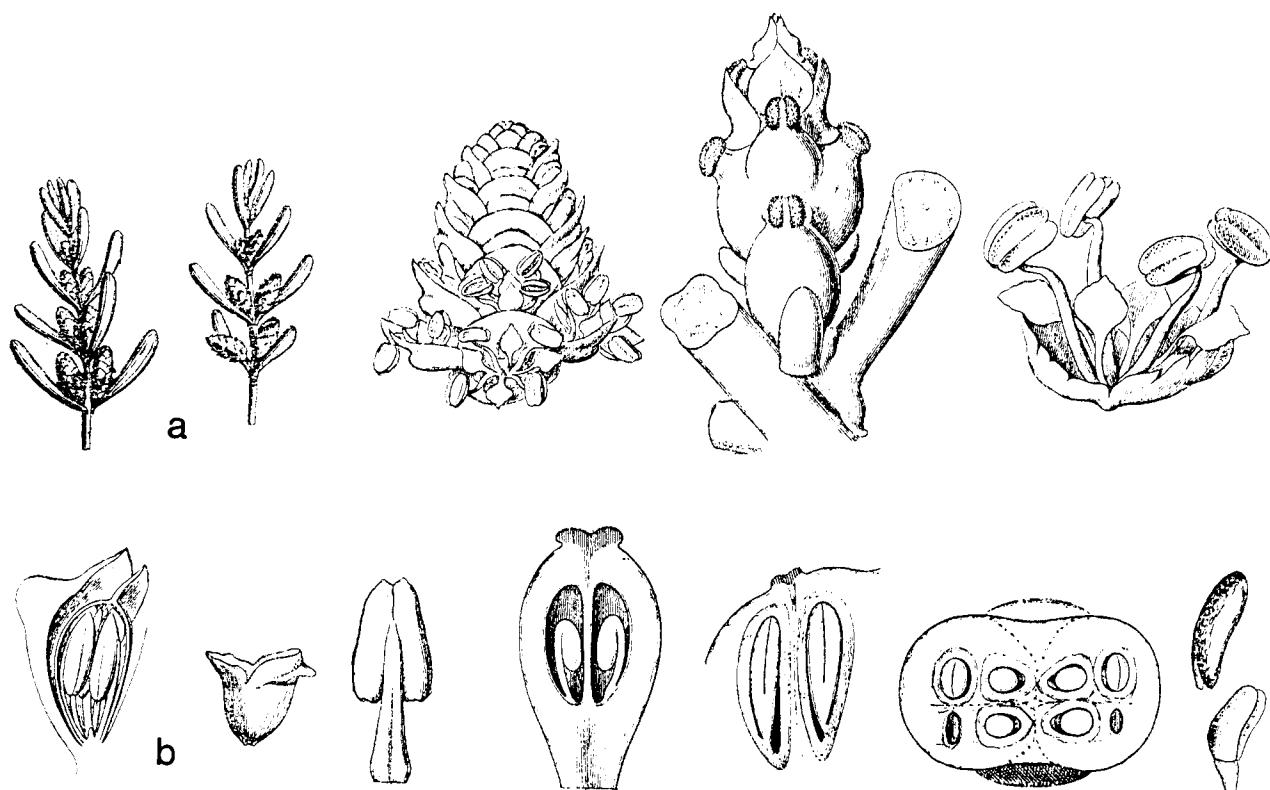


FIGURE 45.—BATACEAE: *a*, *Batis maritima* flowering twig of ♂ plant, flowering twig of ♀ plant, ♂ inflorescence, ♀ inflorescence, ♂ flower; *b*, l.s. of ♂ bud, ♂ calyx, stamen, l.s. of ♀ flower, l.s. and c.s. of fruit, seed and embryo (after Martius, 1840–1906; Le Maout and Decaisne, 1873).

ate to tropical eastern and western America; New Guinea, Queensland, Hawaii, Galapagos.

DILLENIALES

Trees and shrubs, rarely herbs, sometimes climbing; xylem vessel perforation plates mostly scalariform with few to many bars, sometimes also simple; leaves alternate, rarely opposite, simple, usually toothed, rarely pinnatifid or lobed, often with numerous parallel veins extending from the midrib, mostly exstipulate; flowers bisexual or more rarely unisexual, the parts hypogynous; sepals 5 (3–17), free, imbricate; petals 5 (–2), free or shortly connate; stamens numerous, to ~160, rarely as few as 7–10, free, or basally

connate or adnate to the base of the petals, the filaments usually filiform, elongate, the anthers adnate, basifixed or dorsifixed, dehiscent longitudinally or by apical pores; pollen 3-colpate or 3-colporate; pistils 20 to rarely 1, the carpels 1–16 per pistil, styles usually free, rarely connate, elongate, the stigmas apical or slightly decurrent, the ovules numerous to 1 per locule, ventral or axile; fruits follicles or a berry, the seeds minute or moderate-sized and mostly arillate; embryo minute, more rarely elongate and linear; endosperm copious.

Distribution: Pantropical, extending into temperate Australia and temperate eastern Asia.

Chemistry: Alkaloids have not been reported from Dilleniaceae.

DILLENIACEAE (Figure 46*a,b*).—Trees, shrubs,

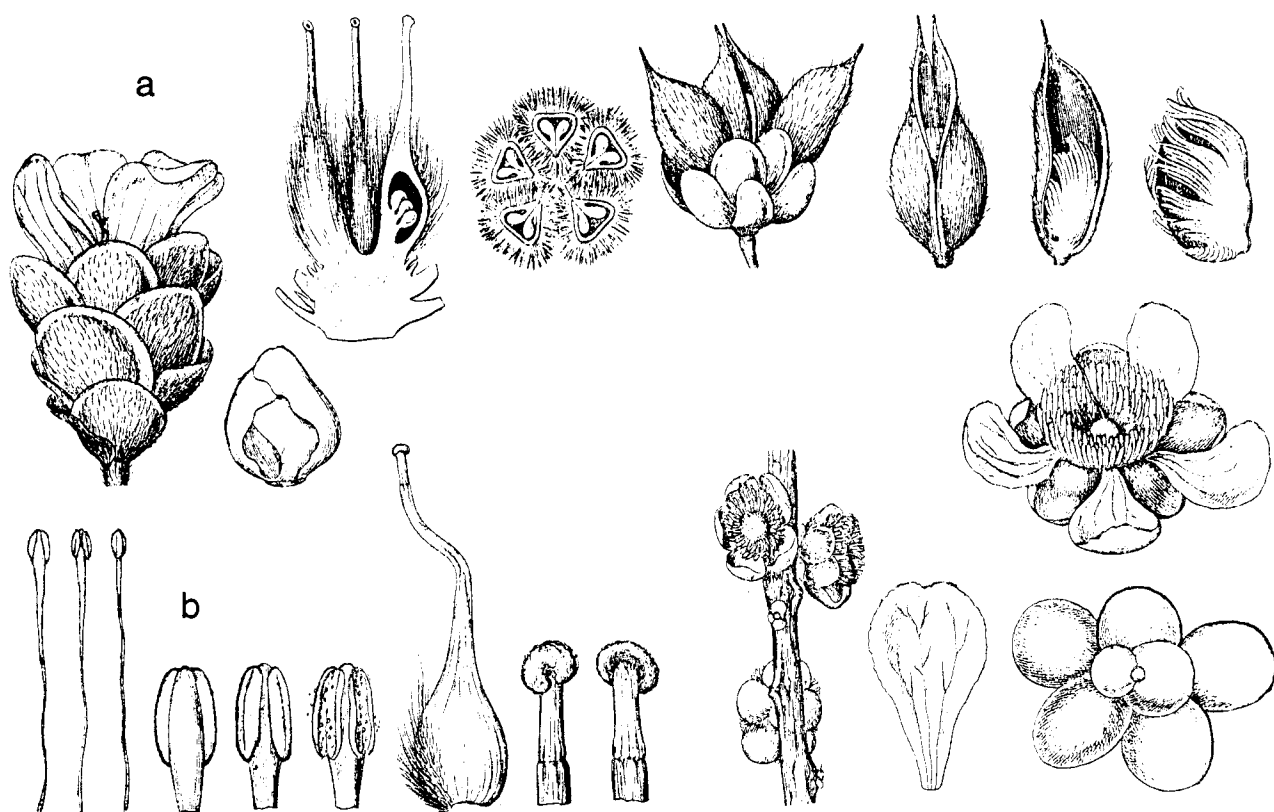


FIGURE 46.—DILLENIACEAE: *a*, *Tetracera alnifolia* flower with bracts, *T. lasiocarpa* corolla in bud, l.s. and c.s. of gynoecium, fruit and calyx, single dehiscent fruitlet, l.s. of fruitlet, seed with aril; *b*, *T. alnifolia* views of stamen, views of anther, pistil, views of stigma, *Doliocarpus grandiflorus* part of flowering twig, petal, flower from above and below (after Martius, 1840–1906).

and twiners, rarely herbs; xylem vessel perforation plates typically scalariform with few to 130 bars, sometimes both simple and scalariform; leaves alternate, rarely opposite, simple, entire or dentate, rarely pinnatifid or trilobed, usually with numerous parallel lateral veins, mostly exstipulate, sometimes the stipules wing-like and adnate to the petiole; inflorescences cymose, racemes, panicles, or the flowers solitary; flowers bisexual or rarely the plants polygamodioecious, the parts hypogynous; sepals 5 (3–17), free, imbricate, or spirally arranged, persistent, often accrescent; petals 5 (–2), free, imbricate, yellow or white, often crumpled in bud; stamens numerous, to ~160, rarely 7–10, free or basally connate, development centrifugal, usually persistent, staminodes often present; filaments filiform

or thickened apically, as long as or longer than the anthers; anthers oblong, nearly twice as long as wide, or small or didymous, usually adnate or basifixed, the connective sometimes apically produced, dehiscing longitudinally or by apical pores; pollen 3-colpate and 3-colporate; receptacle sometimes convex; pistils several, 20 to rarely 1, sometimes slightly united to a columella, the styles free, elongate, and divergent, the stigmas apical; ovule 1 or several, basal, ventral, or axile, bitegmic, crassinucellar, anatropous, campylotropous, or amphitropous; fruitlets follicles, dehiscent along the ventral and rarely also dorsal suture, or baccate; seeds 1 or few, mostly with a crested or lacinate aril; embryo minute; linear, straight, 0.05–0.1 the length of the endosperm; cotyledons not broadened, 0.3–0.5 the length of

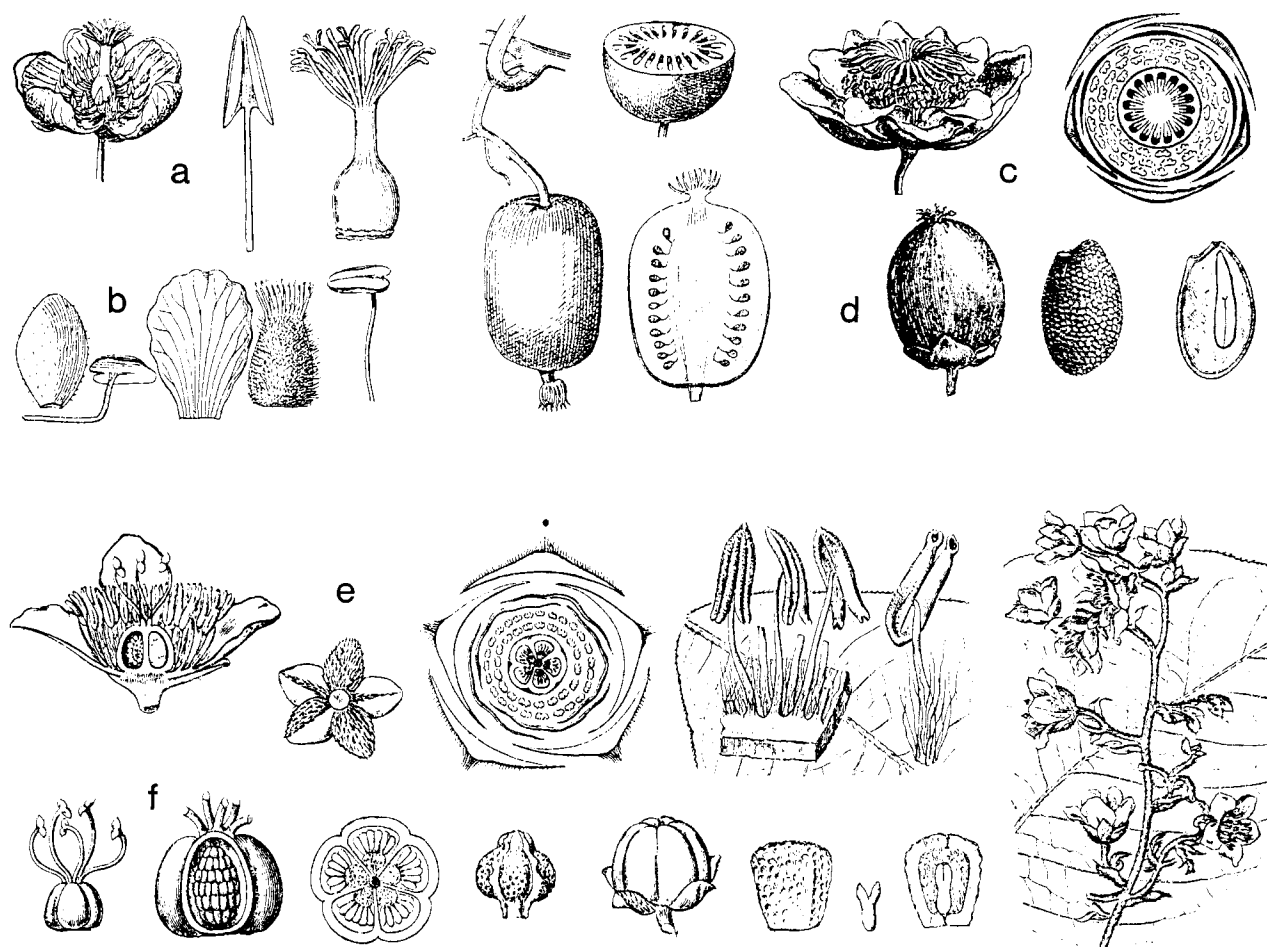


FIGURE 47.—ACTINIDIACEAE: *a*, *Actinidia polygama* flower, stamen, pistil, fruit, c.s. and l.s. of same; *b*, *A. holotricha* sepal, stamen, petal, pistil, another view of stamen; *c*, *A. strigosa* flower, floral diagram; *d*, fruit, seed, l.s. of same (after Lavallée; Finet and Gagnepain; Baillon, 1866–1895). SAURAUACEAE: *e*, *Saurauia bullosa* l.s. of flower, calyx from below, floral diagram, stamens from a bud, stamen at anthesis, part of inflorescence; *f*, pistil, ovary with 1 carpel opened to show ovules, c.s. of ovary, columella, fruit, seed, embryo, l.s. of seed (after Martius, 1840–1906).

the embryo; endosperm copious, fleshy, oily and proteinaceous.

Composition: 14 genera, ~400 species.

Distribution: Pantropical; temperate Australia; centered in Australia, rare in Africa.

ACTINIDIACEAE (Figure 47*a–d*).—Shrubs, often climbing; xylem vessel perforation plates mostly scalariform, with numerous bars, simple plates also present; leaves alternate, simple, serrate, exstipulate; inflorescences axillary cymes or fascicles, rarely the flowers subsolitary; flowers

bisexual or the plants polygamous or dioecious, the parts hypogynous; sepals 5, free, imbricate; petals 5, free; stamens numerous (~50) to 10, the filaments filiform, elongated; anthers twice as long as wide, dorsifixed, inflexed in bud, dehiscent longitudinally or by pores; pollen usually 3-colporate; pistil 1, the carpels 5–16, the styles free and divaricate, or united (*Clematoclethra*), the stigmas papillose, apical, slightly decurrent; ovary 5–16-locular, the ovules numerous, axile, unitegmic, tenuinucellar, anatropous; fruit a

berry, the seeds small; embryo linear, straight, 0.75–0.8 the length of the endosperm; cotyledons about as broad as the radicle, 0.25–0.5 the length of the embryo; endosperm copious, fleshy.

Composition: 2 genera, 50 species.

Distribution: Eastern Asia.

SAURAUACEAE (Figure 47*e,f*).—Trees or shrubs; xylem vessel perforation plates scalariform, with numerous bars (to 50); leaves alternate, simple, usually serrate, the major lateral veins marked and parallel, exstipulate; inflorescence axillary or cauliflorous panicles (cymose?); flowers usually bisexual, small to medium-sized, the parts hypogynous; sepals 5, imbricate, free; petals 5, free or shortly connate, stamens numerous (~150) adnate to the base of the petals, the filaments filiform, elongate; anthers oblong, about 5 times longer than wide, dorsifixed, dehiscent by apical pores or short slits; pollen usually 3-colporate; pistil 1, the carpels 3–5, the styles 3–5, free or united, the stigmas apical; ovary 3–5-locular, the ovules numerous, axile, unitegmic, tenuinucellar, anatropous; fruit a berry, the seeds small; embryo straight or bent, 0.8 the length of the endosperm; cotyledons as wide as the radicle, 0.4 the length of the embryo; endosperm copious, mostly mealy.

Composition: 1 genus, 300 species.

Distribution: Tropical Asia and America.

THEALES

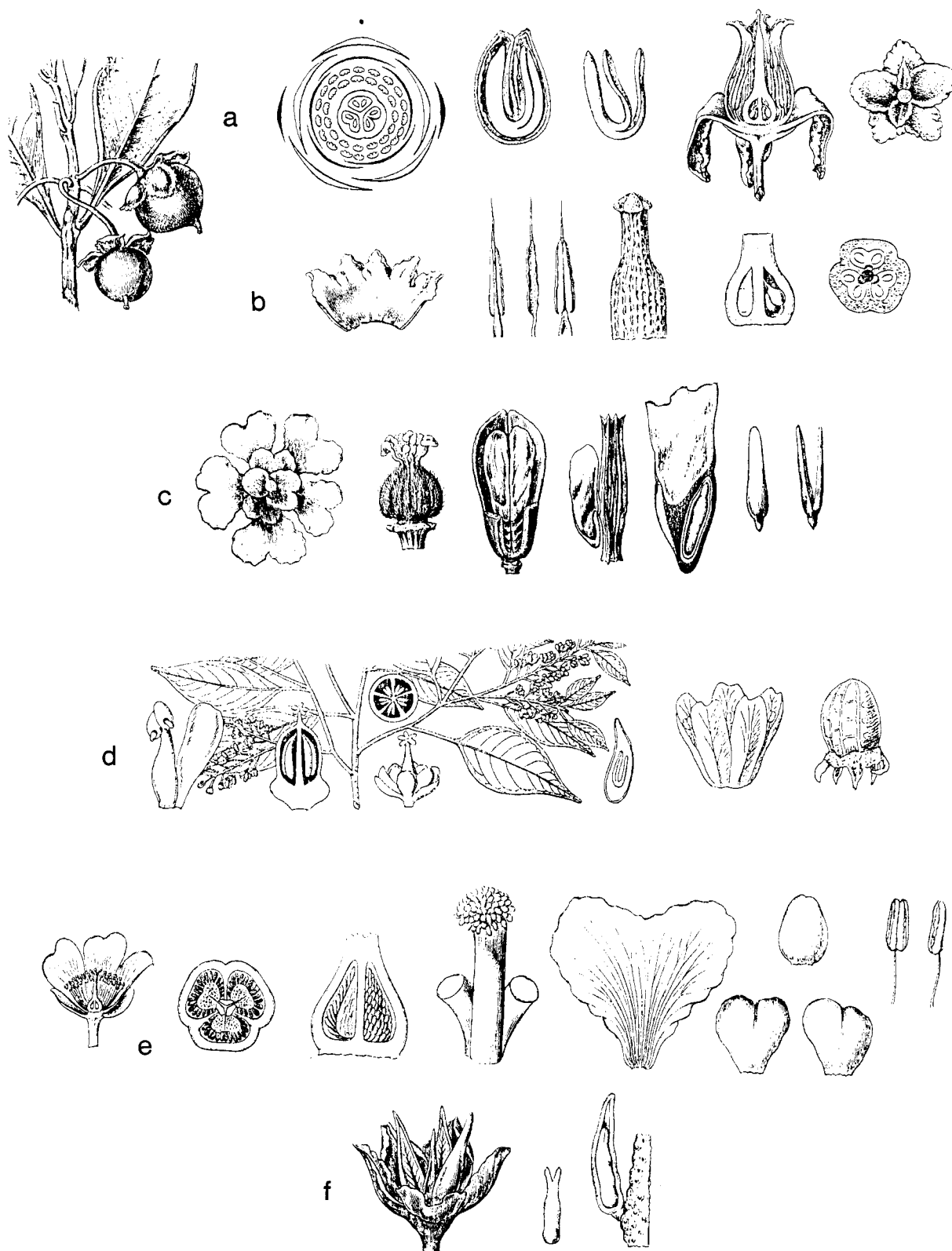
Trees and shrubs, more rarely herbs, sometimes climbing, sometimes with resinous or mucilaginous sap or gland-dotted or resinous tissues; xylem vessel perforation plates scalariform, with numerous or few bars, or simple, sometimes cortical vascular bundles present; leaves alternate or opposite, simple, rarely pinnatifid or compound, toothed or entire, stipulate or exstipulate; flowers bisexual or more rarely unisexual, the parts hypogynous or more rarely perigynous, very rarely epigynous; sepals 5 (2–14), free or connate, usually imbricate, sometimes unequal, sometimes accrescent; petals 5 (0, 2–16) in 1 or rarely 2 whorls, free or shortly connate, rarely calyptrate; stamens usually numerous, 30 to

~1000, more rarely 3–15, in 1–several whorls, free or basally connate, sometimes in bundles, sometimes adnate to the base of the petals; staminal nodes sometimes present; anthers basifixed or dorsifixed, rarely adnate, sometimes didymous, the connective sometimes apically produced, dehiscent longitudinally, rarely by apical pores; pollen 3(2–6)-colporate, less commonly 2–3-colpate or 3(2–4)-porate, rarely 4-rupate or ruplicate; pistils 1, very rarely only connate basally, or 3, the carpels 3–5 (2–25), styles free, connate half way or to the apex, the stigmas usually apical, more rarely sessile, very rarely decurrent; ovary sometimes basally surrounded by a glandular disk, 3–5 (2–25)-locular, the ovules 1–many per locule, axile or rarely parietal or basal, sometimes tenuinucellar; fruit a loculicidal or septicidal, rarely also ventricidal capsule, often leaving a columella, or berry or drupe, rarely a nut or schizocarp; embryo usually large, straight or curved; endosperm most commonly absent, sometimes moderate, least often copious.

Distribution: Pantropical, especially America and Asia, uncommon in temperate regions.

Chemistry: Secretory cavities of various types occur in most of the families. Theobromine occurs in Theaceae, most Sterculiaceae, Aquifoliaceae, and Sapindaceae. Alkaloids are rare. Some alkaloids highly characteristic of the "Polycarpiceae," such as protoaporphines, aporphines, berberin, and other quaternary bases, are absent from the Theales. The order contains trihydroxylated phenolic substances. These are absent

FIGURE 48.—THEACEAE: *a*, *Ternstroemia alnifolia* fruiting twig, floral diagram, l.s. of seed, embryo, *T. candolleana* l.s. of flower, calyx from below; *b*, corolla laid open, views of stamen, part of style and stigma, l.s. and c.s. of ovary; *c*, *Laplacea semiserrata* flower from below, pistil, fruit opened to show seeds, seed on columella, l.s. of seed, views of embryo (after Martius, 1840–1906). PENTAPHYLACACEAE: *d*, *Pentaphylax euryoides* stamen and petal, inflorescence, l.s. and c.s. of ovary, flower without stamens, l.s. of seed, *P. malayana* corolla and stamens, fruit (after Ridley; Hutchinson, 1973). BONNETIACEAE: *e*, *Bonnetia paniculata* l.s. of flower, c.s. and l.s. of ovary, one of the 3 stigmas, *B. sessilis* petal, three of the sepals, views of stamen; *f*, *B. anceps* dehiscent fruit, embryo, l.s. of seed attached to placenta (after Martius, 1840–1906).



from the "Polycarpicae." Quercetin occurs in many. Saponins are often present in the Clusiaceae. The Juglone test is negative and no cyanogenesis occurs. Aucubin (iridoid) glycosides are very rare. Theaceae and Symplocaceae show strong tendency to accumulate aluminum.

THEACEAE (Figure 48a-c).—Trees and shrubs; xylem vessel perforation plates scalariform, often with many bars (to 100), vessel members very long; leaves alternate, simple, dentate or crenate, often distichous, exstipulate; flowers mostly solitary and axillary, rarely a panicle or raceme, bisexual or rarely the plants dioecious (*Eurya*), often large, the parts hypogynous, very rarely perigynous or epigynous; sepals 5 (4–7), free or shortly connate, imbricate; petals 5 (4–8), free or shortly connate, sometimes spirally arranged; stamens numerous (to ~85), rarely 5, 10, or 15, free or shortly connate, sometimes adnate to the base of the petals, sometimes in 5 bundles, the filaments filiform, usually longer than the anthers; anthers about twice as long as wide, basifixed or dorsifixed, the connective sometimes apically produced, dehiscing longitudinally, very rarely by apical pores; pollen 3-colporoidate; pistil 1, the carpels 3–5 (2–10), very rarely only united basally, the styles free half way, or connate, the stigmas decurrent or apical; ovary usually 3–5-locular, the ovules (1–)2 or several per locule, axile, bitegmic, tenuinucellar, anatropous, rarely becoming campylotropous; fruit a loculicidal or septicidal capsule, often leaving a columella, or berry or drupe; embryo large, straight or arcuate, 0.9 as long as the endosperm; cotyledons terete or thin, sometimes folded or thick and plano-convex, 1–3.5 times the width of the radicle, 0.5–0.9 the length of the embryo, the radicle sometimes invested, the plumule evident; endosperm moderate or 0.

Composition: 17 genera, ~500 species.

Distribution: Centered in tropical and subtropical America and Asia; few species in temperate regions; southeastern United States; temperate China; tropical western Africa, Madagascar; northeastern Australia.

PENTAPHYLACACEAE (Figure 48d).—Shrubs

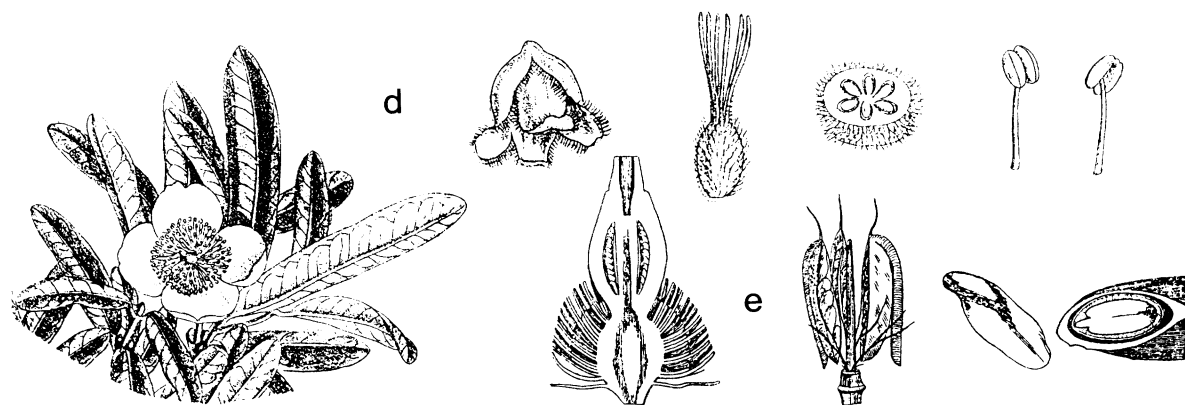
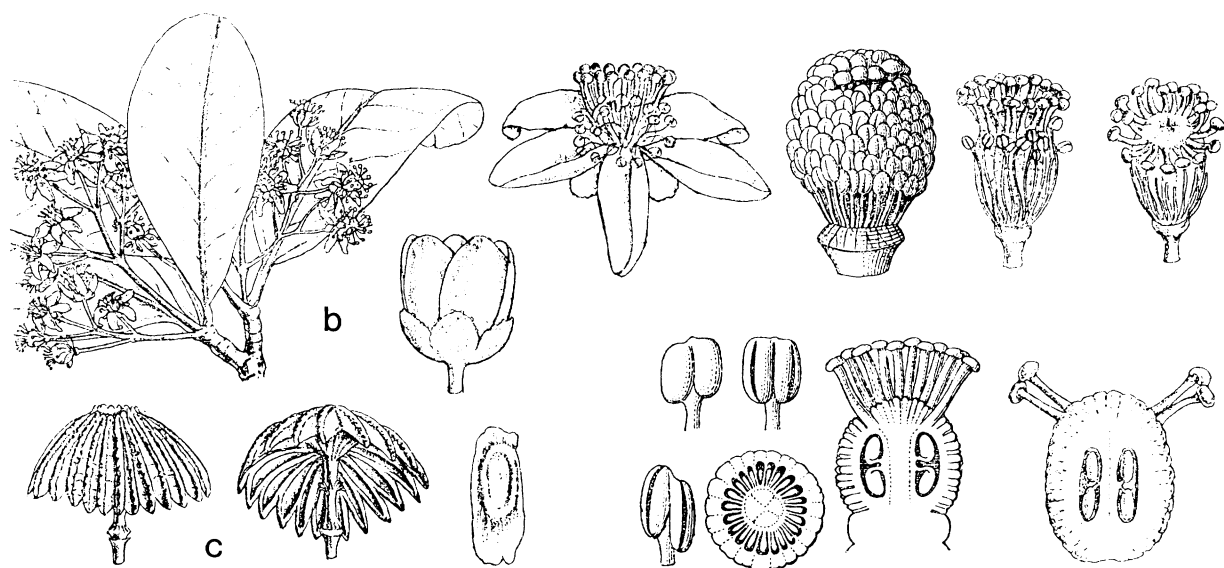
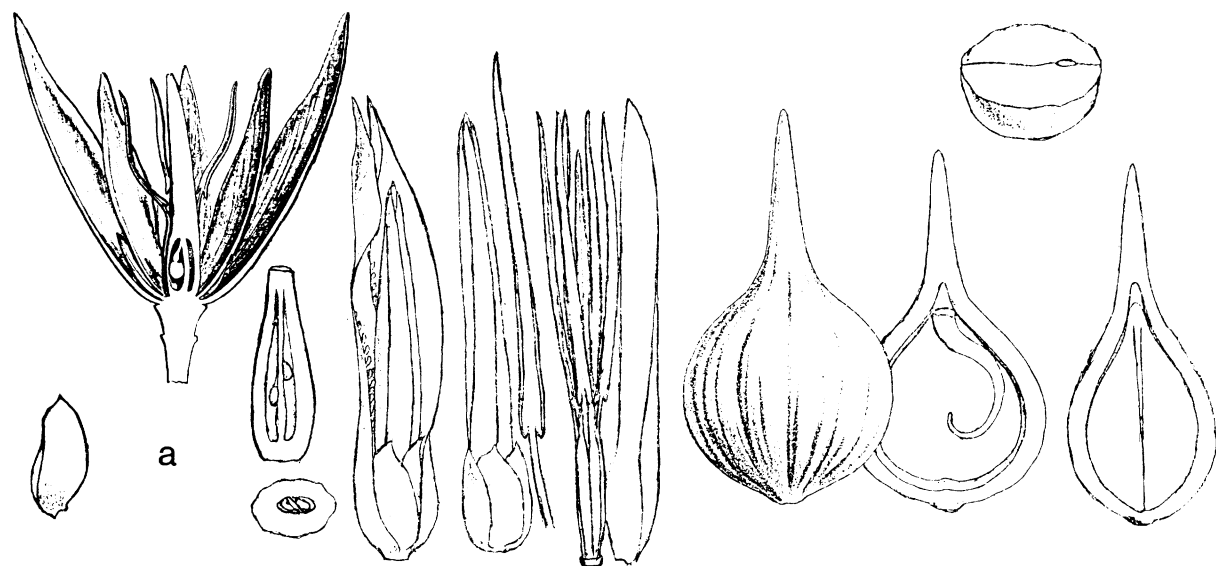
and small trees, the buds perulate; xylem vessel perforation plates scalariform, usually with about 15 bars but sometimes more than 25; leaves alternate, coriaceous, simple, entire, exstipulate; inflorescences axillary and terminal racemes or racemiform; flowers bisexual, small; sepals 5, free; petals 5, free or shortly connate; stamens 5, the filaments thick, broad, connivent, sometimes adnate to the petals; anthers basifixed, didymous, dehiscing by apical lidded pores; pollen 3-colporoidate (-colporate); disk absent; pistil 1, the carpels 5, style 1, stigmas 5, apical; ovary superior, 5-locular, the ovules 2 per locule, axile-subapical, bitegmic, crassinucellar, anatropous or campylotropous; fruit a loculicidal capsule, with a columella; embryo U-shaped; cotyledons as wide as the radicle, 0.5 the length of the embryo; endosperm scanty.

Composition: 1 genus, 2 species.

Distribution: Southern China to Malaya and Sumatra.

BONNETIACEAE (Figure 48e,f).—Trees, rarely shrubs, sometimes resinous; xylem vessel perforation plates simple, rarely also scalariform, with a few bars; leaves alternate, rarely opposite, entire, exstipulate; inflorescence terminal or axillary toward the tip of the branches, panicles, racemes or umbelliform; flowers bisexual, the parts hypogynous; sepals 5, imbricate, unequal, free; petals 5, contorted, free; stamens numerous (~100), the filaments filiform, free or connate basally into 5 bundles; anthers small, about as

FIGURE 49.—PELLICIERACEAE: a, *Pelliciera rhizophorae* sepal, l.s. of flower, l.s. and c.s. of ovary, flower with bracts, flower with bracts removed, stamen, stamens and pistil, petal, fruit, longisections of fruit showing plumule and cotyledons, c.s. of seed (above) (after Hemsley). MEDUSAGYNACEAE: b, *Medusagyne oppositifolia* flowering branch, partially open flower, fully open flower, essential organs, essential organs with some stamens removed, pistil and some filaments; c, views of dehiscent fruit, seed (enlarged), views of anther, c.s. and l.s. of pistil, l.s. of pistil (after Hemsley, Engler and Melchior). EUCRYPHIACEAE: d, *Eucryphia billardieri* flowering twig, calyptriform calyx, pistil, c.s. of ovary, views of stamen; e, *E. cordifolia* l.s. of ovary and base of androecium, part of dehiscent fruit, seed, l.s. of same (after Hooker and Hooker, 1837–1982; Focke).



long as wide, dorsifixed; pollen 3-colporate; pistil 1, the carpels 3 or 5, the style 1 or 3- or 5-fid; ovary 3–5-locular, the placentas axile, thick, the ovules usually numerous; fruit a septicidal capsule, leaving a columella; embryo straight, the cotyledons as wide as or narrower than the radicle, 0.2–0.3 the length of the embryo; endosperm present or 0.

Composition: 3 genera, 22 species.

Distribution: Mostly in swampy or coastal regions; tropical Asia and America.

PELLICIERACEAE (Figure 49a).—Buttressed mangrove tree; xylem vessel perforation plates simple; leaves alternate, simple, involute in bud, coriaceous, exstipulate; flowers axillary, solitary, large, bisexual, the parts hypogynous; sepals 5, imbricate, short, free, at first white, then rose like the petals; petals 5, elongated, free; stamens 5, the filaments free, slightly shorter than the large, linear anthers; anthers at least 10 times longer than wide, basifixed; pollen 3-colporate; pistil 1, the carpels 2, the style 1, stigma bifid, apical; ovary conic-cylindric, bilocular, the ovules 1 per locule, axile; fruit a large, long-acuminate, coriaceous nut, the seed 1, large; cotyledons broad, thick, plano-convex, radicle short, plumule long; endosperm 0.

Composition: 1 genus, 1 species.

Distribution: Pacific shores from Costa Rica to Ecuador.

MEDUSAGYNACEAE (Figure 49b,c).—Shrubs, xylem vessel perforation plates simple, cortical bundles present in the stem; leaves opposite, simple, obscurely crenate, exstipulate; inflorescence a short, lax, deltoid, terminal panicle; flowers bisexual, the parts hypogynous, the stamens and styles included; sepals 5, imbricate, basally connate; petals 5, free, imbricate and contorted in bud; stamens about 100, at 4–5 levels, the filaments filiform, free; anthers small, as long as wide, basifixed, sometimes the sacs slightly separated at base by connective and not at the same height; pollen 3(2–4)-porate; pistil 1, the carpels 17–25, the styles free, on the shoulders of the carpels, the stigmas capitate; ovary 17–25-locular, the ovules 2(3) per locule, axile; fruit a cap-

sule, septicidally dehiscent from the base, leaving a columella; seeds small, winged; embryo clavate, the cotyledons ovate, nearly equal to the radicle in length(?); endosperm very scanty.

Composition: 1 genus, 1 species.

Distribution: Seychelles Islands.

EUCRYPHIACEAE (Figure 49d,e).—Trees and shrubs; xylem vessel perforation plates typically all scalariform, usually with 20 or fewer bars but occasionally to 40; leaves opposite, simple or pinnately compound, serrate, stipulate; flowers axillary, solitary, bisexual, the parts hypogynous; sepals 4 (–5), imbricate, connate apically, deciduous; petals 4 (–5), large, free; stamens numerous (~200), free, the filaments filiform; anthers small, about as long as wide, dorsifixed; pollen 2-colpate; pistil 1, the carpels 5–12 (4–18), the styles free, filiform, stigmas apical, inconspicuous; ovary 5–12(4–18)-locular, the ovules several per locule, axile; fruit a septicidal capsule, each carpel also ventrally dehiscent, leaving a columella; seeds winged, the embryo large; cotyledons foliaceous, moderately thick, plano-convex, the radicle short; endosperm scanty, fleshy.

Composition: 1 genus, 5 species.

Distribution: Temperate Southern Hemisphere; New South Wales, Tasmania, Chile.

PARACRYPHIACEAE (Figure 50a,b).—Shrubs or small trees; xylem vessel perforation plates scalariform with more than 100 bars; leaves simple, subverticillate, serrate, exstipulate; inflorescence a terminal compound spike; flowers bisexual and ♂; sepals (bracts?) 2–3; petals 0; stamens 8–10 (–16), the filaments hypogynous or subperigynous; anthers oblong, twice as long as wide, basifixed; pollen tricolporate; pistil 1, costate-cylindrical, the apex truncate, the carpels 12–15, the stigmas 12–15, sessile; ovary superior, 12–15-locular, the ovules few per locule, 1-seriate; fruit a septicidal capsule, leaving a columella; seeds not seen.

Composition: 1 genus, 2 species.

Distribution: New Caledonia.

SYMPLOCACEAE (Figure 50c–e).—Trees and shrubs; xylem vessel perforation plates scalariform, usually with more than 20 bars; leaves

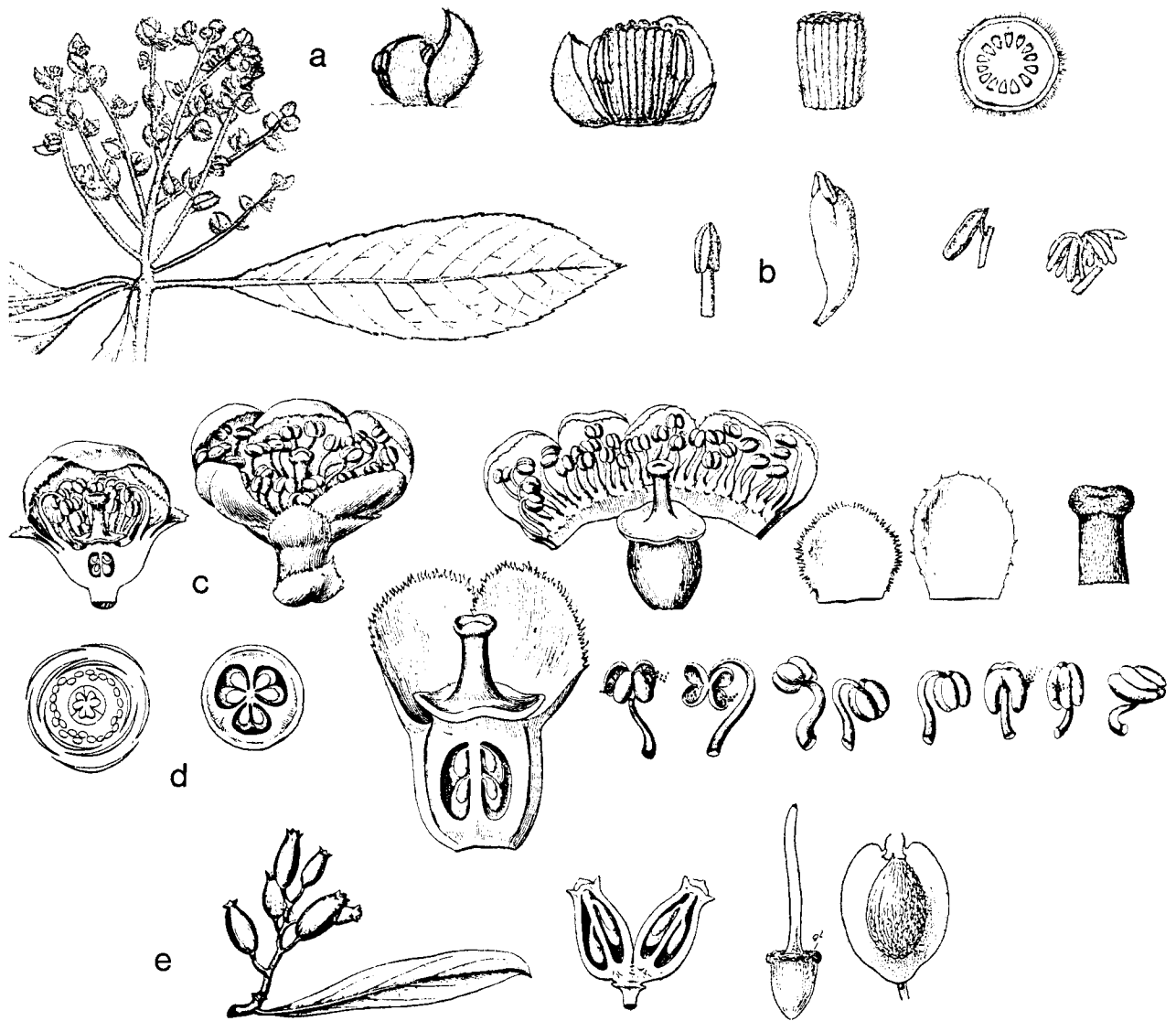


FIGURE 50.—PARACRYPHIACEAE: *a*, *Paracryphia suaveolens* flowering twig, flower, flower with part of perianth removed, pistil, c.s. of ovary; *b*, stamens, single carpel of fruit, dehiscent fruit (after Baker). SYMPLOCACEAE: *c*, *Symplocos lanceolata* l.s. of bud, flower, flower laid open, sepal, corolla lobe, stigma; *d*, floral diagram, c.s. of ovary, l.s. of ovary, views of stamen; *e*, fruits, l.s. of same, *S. paniculata* pistil with epigynous glandular disk, l.s. of fruit (after Martius, 1840–1906; Johnson).

alternate, simple, serrate or entire, exstipulate; inflorescences axillary or terminal panicles, spikes, racemes or fascicles, or the flowers solitary; flowers bisexual, or rarely the plants polygamodioecious, the parts perigynous or epigynous; sepals 5, connate, persistent; petals 5 (3–11), connate basally in 1–2 series; stamens 4–

numerous (to ~100), in 1–4 whorls, the filaments free or connate basally, sometimes in 5 bundles, inserted on the base of the corolla; anthers small, as long as wide; pollen 3(2–4)-colporate, the colpi short; pistil 1, the carpels 2–5, the style 1, elongate, stigmas apical, capitate or 2–5-lobed; ovary semi-inferior, 2–5-locular, the ovules 2–4 per

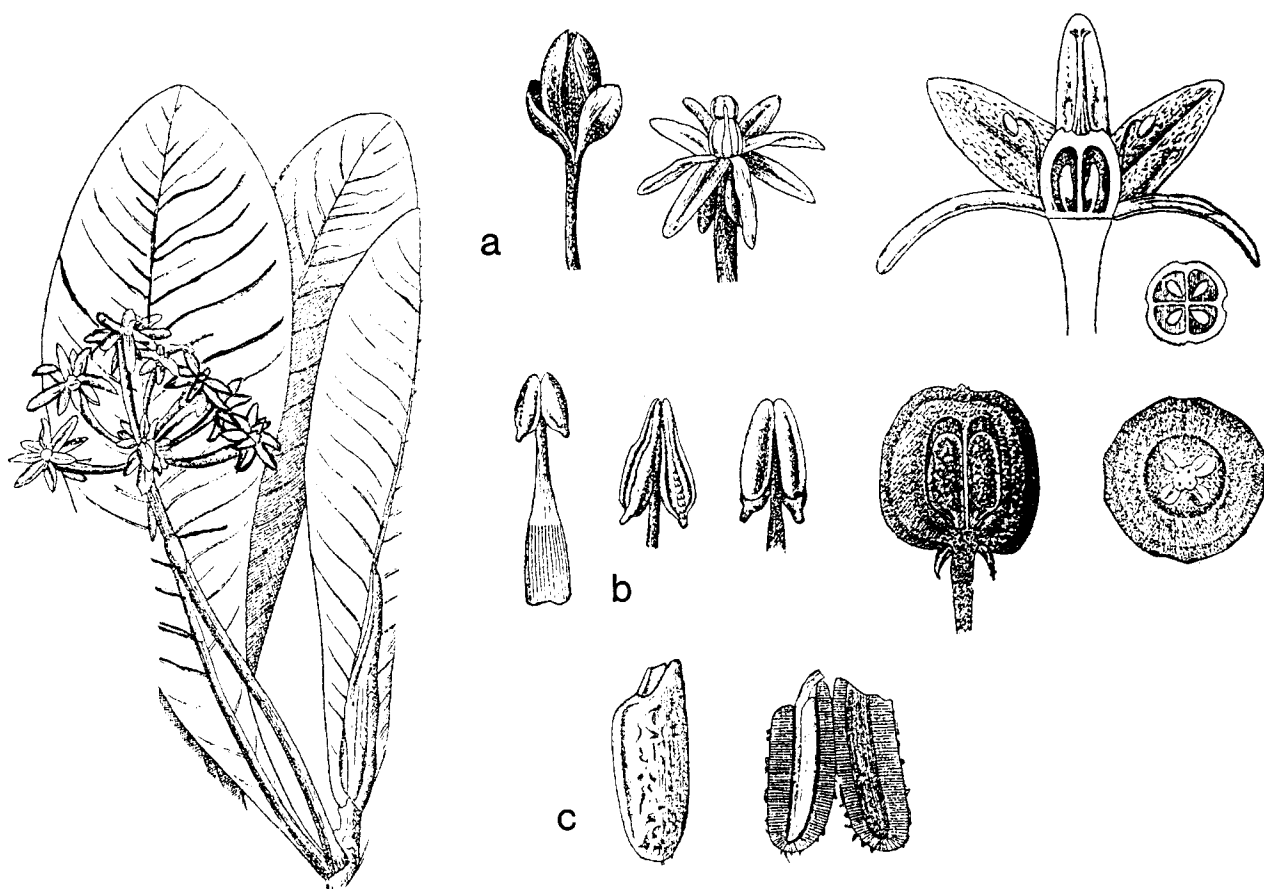


FIGURE 51.—TETRAMERISTACEAE: *a*, *Tetramerista glabra* flowering twig, bud, flower, l.s. of same, c.s. of ovary; *b*, stamen, views of anther, l.s. and c.s. of fruit; *c*, immature pyrene, the same opened (after Boerlage and Koorders).

locule, axile, unitegmic, tenuinucellar, anatropous; fruit a berry or drupe; embryo linear, straight or arcuate, 0.7–0.95 the length of the endosperm; cotyledons 0.1 the length of the embryo; endosperm copious.

Composition: 1 genus, ~400 species.

Distribution: Centered in tropical and subtropical America and Asia; southern United States; Japan; northeastern Australia, southwestern Pacific Islands; absent from Africa and western Eurasia.

TETRAMERISTACEAE (Figure 51*a–c*).—Trees and shrubs; xylem vessel perforation plates usually simple, sometimes also scalariform with about 8 bars; leaves alternate, simple, entire, asymmetric, coriaceous, glandular-punctate be-

low, exstipulate; inflorescences axillary umbelliform racemes; flowers bisexual, the parts hypogynous; perianth glandular-punctate; sepals 4, imbricate in 2 series, shortly connate basally; petals 4; stamens 4, the filaments elongate, flattened basally; anther thecas separate and divergent basally, the connective basally produced and glandular; pollen 3-colporate; pistil 1, the carpels 4, the style 1, subulate, stigmas 4, minute, apical; ovary 4-locular, the ovules 1 per locule, basal; fruit a berry, the exocarp coriaceous, mesocarp fleshy; seeds 4, oblong; endosperm 0.

Composition: 1 genus, 3 species.

Distribution: Malaya and western East Indies.

CLUSIACEAE (Figure 52*a–c*).—Trees and shrubs, the sap resinous; xylem vessel perforation

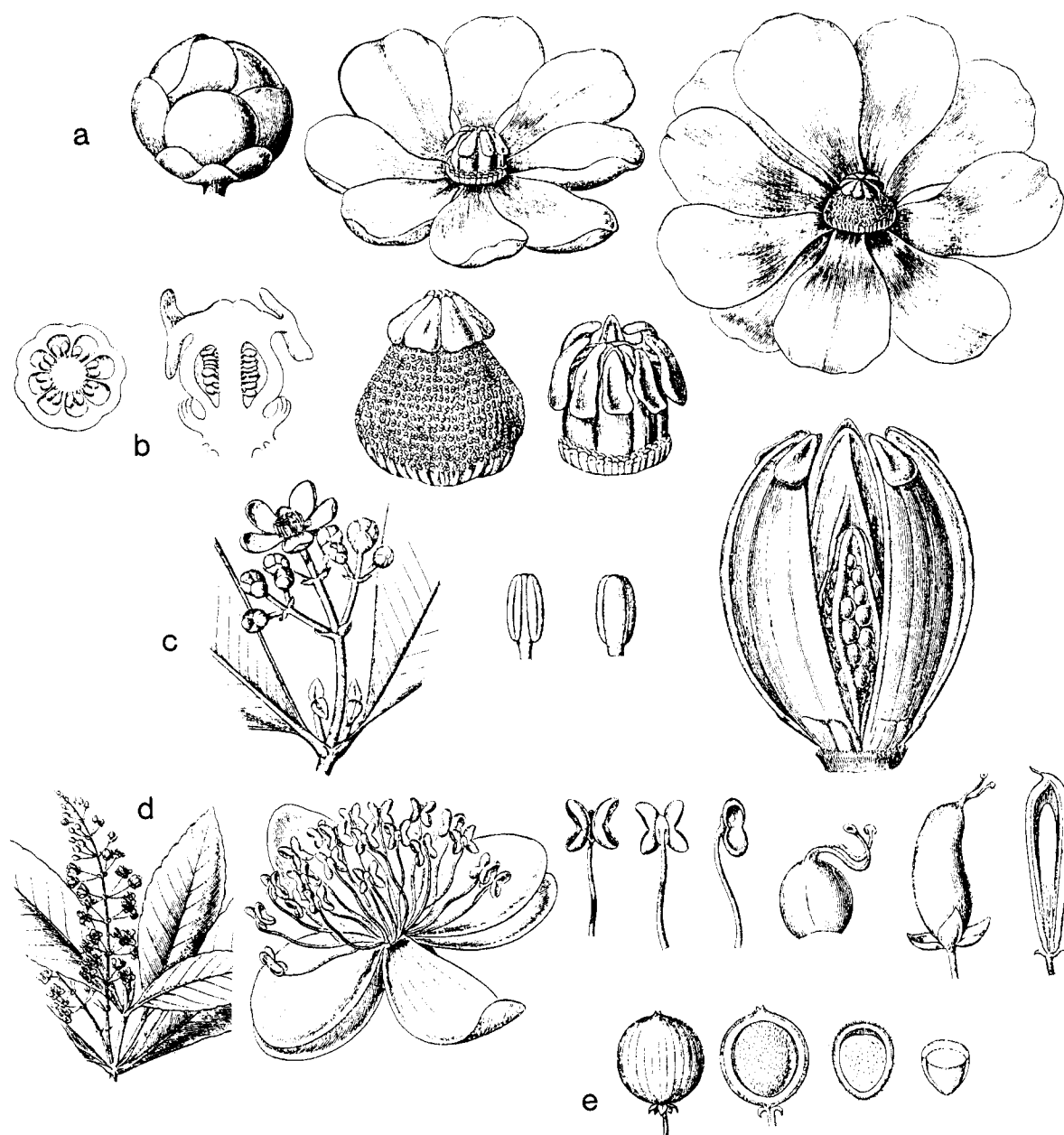


FIGURE 52.—CLUSIACEAE: *a*, *Clusia arrudea* ♂ bud, ♀ flower, ♂ flower; *b*, c.s. and l.s. of ovary, androecium, pistil and staminodes; *c*, *C. cambessedesii* inflorescence, views of stamen, *C. planchoniana* dehiscent fruit (after Martius, 1840–1906). QUIINACEAE: *d*, *Quiina glaziovii* flowering twig, *Q. macrostachya* ♂ flower, views of stamen, *Q. rhytidopus* pistil, immature fruit, *Q. sessilis* l.s. of fruit showing the seed; *e*, *Q. obovata* fruit, l.s. of same showing the seed, l.s. of seed, c.s. of embryo (after Martius, 1840–1906).

plates simple to scalariform with numerous bars; leaves opposite, simple, entire, exstipulate; inflorescences cymes, sometimes umbellate, or the flowers solitary; flowers bisexual, or the plants polygamous or dioecious, the parts hypogynous; sepals 6–2 (–14), imbricate, free; petals 6–2 (–14), free; stamens numerous (to ~1000), rarely few (8 in *Oedematopus*), free or all connate basally, or connate in bundles opposite the petals; anthers often oblong, adnate or basifixed; staminodes often present in ♀ flowers; pollen 3(2–5)-colporate; pistil 1, the carpels 5 or 3 (1–15), the styles free or connate or absent, the stigmas often shield-shaped, lobed or radiate, sometimes small; ovary 1–several locules, the ovules 1–many per locule, axile or basal, rarely parietal, bitegmic, crassinucellar or tenuinucellar, anatropous or semianatropous; fruit often a septicidal capsule or berry, rarely a drupe (*Endodesmia*); seeds large, often arillate; embryo straight, sometimes conferruminate; cotyledons sometimes 4 times wider than the radicle, 0.9 the length of the embryo, sometimes 0.05 the width of the macropodal radicle and 0.07 the length of the embryo; endosperm 0.

Composition: 35 genera, 400 species.

Distribution: Pantropical in moist regions, relatively few in Africa.

QUINACEAE (Figure 52*d,e*).—Trees, shrubs, and climbers; xylem vessel perforation plates simple, rarely also scalariform, lysigenous mucilaginous cavities often in the pith, sometimes resin canals in traumatic tissue, sometimes resin in fruit and petals; leaves opposite or whorled, simple, sometimes pinnatifid or imparipinnately compound, the margins entire or crenate, lateral veins numerous, tertiary veins feather-veined, stipulate; inflorescences axillary or terminal racemes or panicles; flowers bisexual or the plants polygamodioecious, the parts hypogynous; sepals 4–5, sometimes unequal in size, free or nearly free; petals 4–8, free; stamens 15–200+, the filaments filiform, free or basally connate, sometimes inserted on the base of the petals; anther thecas small, about as long as wide, didymous; pollen 3-colporate; pistils 1 or 3, the carpels

2–14, the styles 2–14, filiform or short, free, stigmas apical; ovary 2–14-locular, the ovules 2 per locule, axile near the base of the locule; fruit baccate but eventually dehiscent; seeds 1–few, often densely hairy; embryo straight, the cotyledons thick, plano-convex, the radicle very short; endosperm 0.

Composition: 4 genera, 50 species.

Distribution: Tropical American forests, especially the Amazon region.

HYPERICACEAE (Figure 53*a,b*).—Mostly shrubs and herbs, sometimes trees, with schizogenous secretory cavities, sometimes resinous (*Vismia*); xylem vessel perforation plates usually simple, sometimes also scalariform; leaves opposite or verticillate, very rarely the lower leaves alternate (*Psorospermum*), simple, entire, usually gland-dotted, exstipulate; inflorescences mostly terminal, cymose-paniculate, or the flowers solitary; flowers bisexual, the parts hypogynous; sepals 4–5, imbricate, free or basally connate; petals 4–5, free, sometimes with a basal nectar scale; stamens numerous (~ 50–200), rarely less than 10 (5), the filaments elongate, free or often connate in 3–5 bundles, or basally monadelphous; anthers dorsifixed, often small, slightly longer than wide; pollen 3-colporate; pistil 1, the carpels 3–5, the styles mostly free, very rarely connate high, stigmas apical; ovary 1- or 3–5-locular, the ovules numerous, axile or rarely parietal, bitegmic, tenuinucellar, anatropous; fruit a loculicidal or septicidal capsule, or berry; seeds minute, not arillate; cotyledons hemi-cylindric, flat or rarely curved, 0.3 the length of the embryo; endosperm 0.

Composition: 8 genera, 350 species.

Distribution: Mainly pantemperate and mountains of the tropics; tropical lowland.

ELATINACEAE (Figure 53*c,d*).—Herbs and shrublets, sometimes aquatic; xylem vessel perforation plates simple; leaves opposite or verticillate, simple, entire or dentate, stipulate; inflorescences axillary, dichasia or the flowers solitary; flowers bisexual, minute, the parts hypogynous; sepals 3–5 (2–6), imbricate, free or basally connate; petals 3–5 (2–6) or 0, free; stamens 3–10,

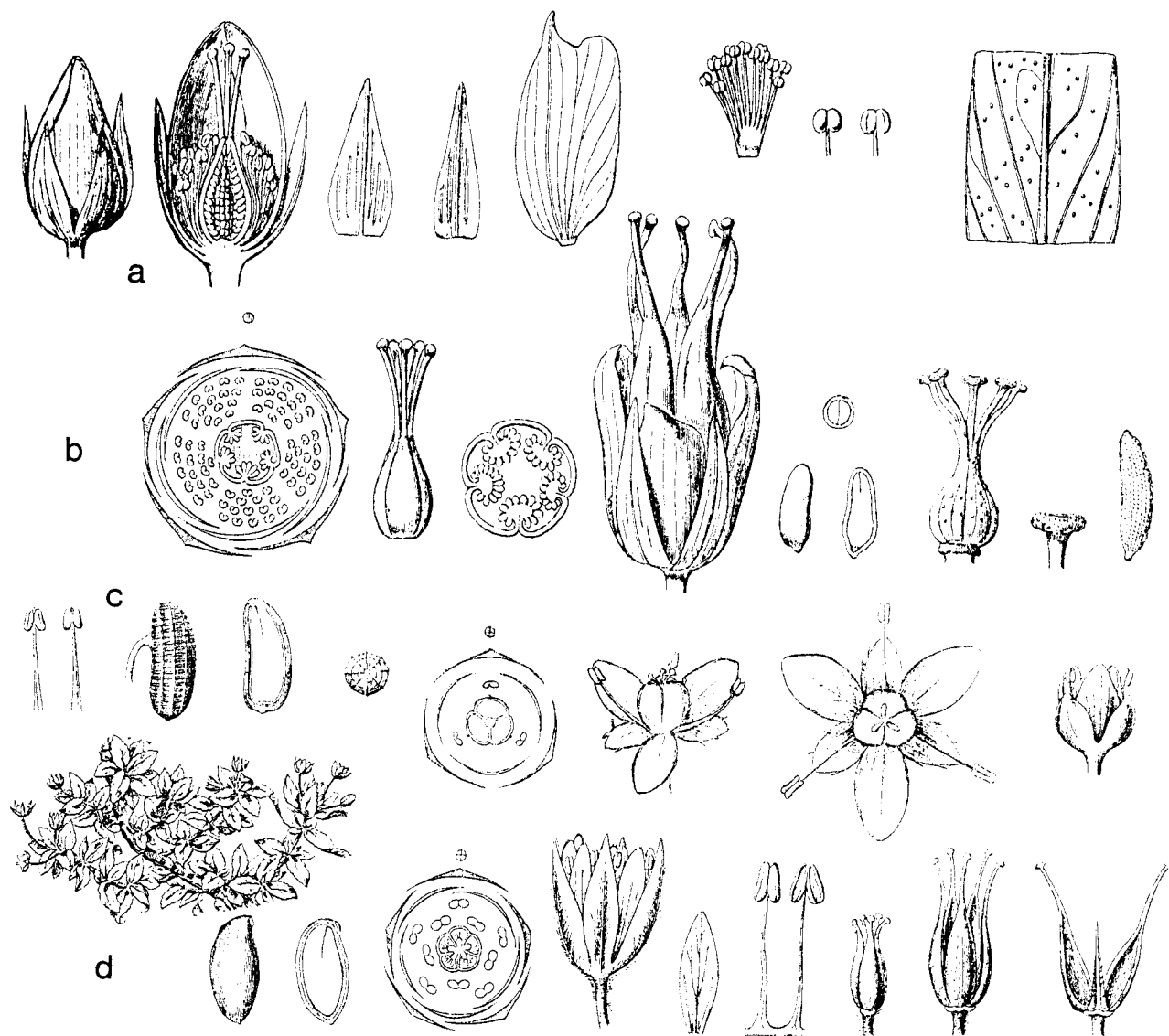


FIGURE 53.—HYPERICACEAE: *a*, *Hypericum brasiliense* bud, l.s. of flower, 2 sepals, petal, staminal phalanx, views of anther, part of leaf showing glands; *b*, floral diagram, pistil, c.s. of ovary, fruit with calyx, seed and c.s. and l.s. of same, *Vismia japurensis* pistil, one of the stigmas, seed (after Martius, 1840–1906). ELATINACEAE: *c*, *Elatine lindbergii* views of stamen, seed, l.s. of same, apical view of seed, floral diagram, flower, same from above, young flower; *d*, *Bergia arenarioides* part of plant in flower, seed, l.s. of same, floral diagram, flower, petal, stamens, pistil, dehiscent fruit, part of fruit and columella (after Martius, 1840–1906).

in 1 or 2 whorls, free, the filaments sometimes subulate; anthers small, as long as wide; pollen 3-colporate; disk absent; pistil 1, the carpels 3–5 (2–6), the styles short, 3–5 (2–6), free, stigmas apical; ovary 3–5 (2–6)-locular, the ovules nu-

merous per locule, axile, bitegmic, crassinucellar, also tenuinucellar (?), anatropous; fruit a septicidal or septifragal capsule, sometimes leaving a columella; seeds minute, sometimes longitudinally and horizontally sculptured; embryo

straight or arcuate; cotyledons not wider than the radicle, 0.2–0.6 the length of the embryo; endosperm 0.

Composition: 2 genera, 40 species.

Distribution: Almost cosmopolitan, absent from arctic Northern Hemisphere.

DIPTEROCARPACEAE (Figure 54*a,b*).—Trees, usually resinous and mucilaginous; xylem vessel perforation plates simple; cortical vascular bundles are characteristic of the young stem; leaves alternate, simple, entire, stipulate; inflorescences axillary or terminal panicles, rarely cymose (*Upuna* and some *Vatica*); flowers bisexual, the parts hypogynous or subperigynous, rarely the calyx adnate to the ovary; sepals 5, connate part way, the lobes imbricate or valvate, often 2–5 accrescent and wing-like in fruit; petals 5, markedly convolute, free or shortly connate basally, often hairy; stamens usually numerous (to ~40), sometimes 5, 10 or 15, frequently adnate to the base of the petals, the filaments short or elongate, usually connate, sometimes in bundles; anthers dorsifixed or basifixed, the connective usually apically produced, dehiscing longitudinally or apically; pollen 3-colpate or colpoidate; pistil 1, the carpels 3 (2 only in *Stemonoporus*), the style simple or 3-lobed, a fleshy stylopodium often present, the stigma small, apical; ovary 3-locular (rarely incompletely so), the ovules 2 per locule, axile, (rarely parietal?), bitegmic, crassinucellar, anatropous; fruit a nut, mostly 1-seeded; embryo large, the cotyledons contorted, and crumpled, and enclosing the radicle, sometimes plano-convex, much wider than the radicle, 0.7 the length of the embryo; endosperm mostly 0.

Composition: 15 genera, ~500 species.

Distribution: Tropical, centered in rain forest of Malaya and the East Indies, extending to India; few in tropical Africa.

HUMIRIACEAE (Figure 54*c–e*).—Trees and shrubs, sometimes resinous; xylem vessel perforation plates exclusively scalariform, with 15–25 bars, the vessel members extremely long; leaves alternate, simple, crenate or entire, stipulate or exstipulate; inflorescences axillary or rarely terminal thyrses; flowers bisexual, the parts hypog-

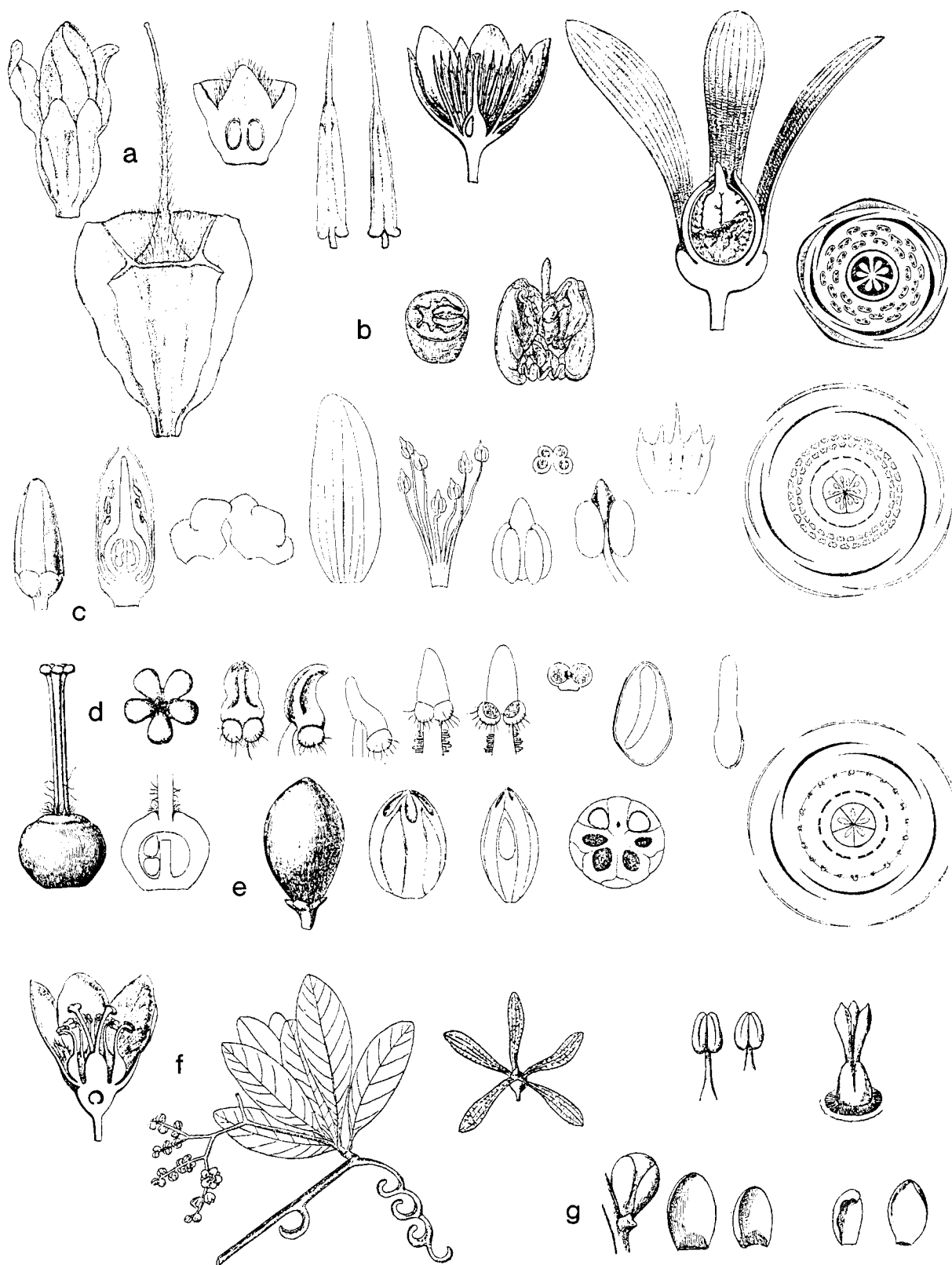
ynous; sepals 5, imbricate, connate part way; petals 5, free; stamens 10, 20, 30, or 50 to 180, in 1–4 whorls, the filaments subulate or filiform, connate basally; anther sacs small, the connective markedly produced apically; pollen 3-colporate, the colpi short; disk cupular or of 10–20 free glandular scales surrounding the base of the ovary; pistil 1, the carpels 5–7, the style simple, stigmas apical; ovary 5–7 locular, the ovules 1–3 per locule, axile, bitegmic, crassinucellar, anatropous; fruit a drupe, the endocarp woody, sometimes ribbed, sometimes with numerous resin-filled cavities; seeds usually 1–2; embryo straight or slightly curved; cotyledons oblong or ovate, often subcordate basally, less than 0.5 to 0.7 the length of the embryo, 1.5 times wider than the radicle; endosperm copious, fleshy and oily.

Composition: 8 genera, 50 species.

Distribution: Tropical America, centered in the Amazon basin; two species in tropical west Africa.

ANCISTROCLADACEAE (Figure 54*f,g*).—Lianas, rarely shrubs, the twigs with coiled hooks; xylem vessel perforation plates simple; leaves alternate, simple, entire, with scattered minute glandular pits, stipulate or exstipulate; inflorescences terminal racemes, panicles or cymes; flowers bisexual, the parts perigynous; calyx adnate to the base of the ovary, the lobes 5, imbricate, accres-

FIGURE 54.—DIPTEROCARPACEAE: *a*, *Dipterocarpus bourdiloni* bud, pistil and base of calyx, l.s. of ovary, views of anther, *Dryobalanops aromatica* l.s. of flower, l.s. of fruit, floral diagram; *b*, *D. camphora* c.s. of seed, embryo unfolded (after Brandis; Baillon, 1866–1895; Lindley). HUMIRIACEAE: *c*, *Vantanea paniculata* bud, l.s. of bud, calyx laid open, petal, part of androecium, views of anther, c.s. of anther, part of hypogynous cupule, floral diagram; *d*, *Humiria balsamifera* pistil, stigma from above, 2 views of anther of longer filament, 3 views of anther of shorter filament, c.s. of anther of longer filament, *H. floribunda* l.s. of seed, embryo; *e*, *H. balsamifera* l.s. of ovary, *H. floribunda* fruit, putamen, l.s. of same, c.s. through middle of same, *Sacoglottis cuspidata* floral diagram (after Martius, 1840–1906). ANCISTROCLADACEAE: *f*, *Ancistrocladus guineensis* l.s. of flower, *A. pinangianus* flowering twig, fruit, *A. harmandii* long and short stamens, pistil; *g*, bud, 2 sepals, 2 petals (after Baillon, 1866–1895; Ridley; Gagnepain).



cent, unequal and wing-like in fruit, often with conspicuous dorsal glandular pits; petals 5, connate basally; stamens 10, rarely 5, uniseriate, the filaments basally broad and connate, apically filiform; anthers basifixed, slightly longer than wide; pollen 3-(4)-colpoidate; pistil 1, the carpels 3, the style 1, stigmas 3; ovary unilocular, ovule 1, basal, bitegmic, semianatropous; fruit a woody nut, the seed large; embryo 0.5 the length of the endosperm; cotyledons divergent, as broad as the radicle, 0.4 the length of the embryo; endosperm ruminant, much folded and coiled, brain-like, starchy.

Composition: 1 genus, 20 species.

Distribution: Tropical western Africa, Sri Lanka, India to Malaya.

MARCGRAVIACEAE (Figure 55*a,b*).—Shrubs, usually climbing and epiphytic, rarely tree; xylem vessel perforation plates simple or both simple and scalariform, with few to many bars, vessel members very long; secretory canals sometimes present; leaves simple, alternate, entire, exstipulate; inflorescences terminal cymose umbels, or spikes; flowers bisexual, the parts hypogynous; bracts modified into pitcher-like, saccate, urn-shaped or spurred, colored nectaries; sepals 4–5, imbricate, free or connate basally; petals 4–5, free or connate basally or calyptrate; stamens numerous (to ~40) to 3, in 1 whorl, free or connate basally and sometimes adnate to the base of the corolla, the filaments broadened toward the base; anthers oblong, 2–5 times longer than wide, basi- or dorsifixed; pollen 3-colporate or colpoidate; pistil 1, the carpels 2–8, the style 1, very short or the stigmas sessile, radiate; ovary initially unilocular, later 2–8-locular, the ovules bitegmic, tenuinucellar, anatropous, numerous, in several series, the placentas thick; fruit a berry with leathery epicarp, eventually slightly loculicidally dehiscent basally; seeds numerous, small; embryo straight or slightly arcuate; cotyledons 1–2 times the width of the radicle, 0.3–0.7 the length of the embryo; endosperm 0.

Composition: 5 genera, ~120 species.

Distribution: Tropical America.

CARYOCARACEAE (Figure 55*c-e*).—Trees and shrubs; xylem vessel perforation plates simple,

occasionally with some scalariform plates; leaves opposite or alternate, digitately compound, the leaflets 3–5, the margins entire, stipulate or exstipulate; inflorescences terminal racemes; flowers bisexual, the perianth hypogynous; sepals 5–6, imbricate or open, connate basally; petals 5–6, free or calyptrate; stamens subperigynous, numerous (~30–60), in 5–6 series, the filaments long, filiform, colored, often warty, free or connate in 1 whorl basally or in 5 bundles, bent in bud, sometimes some lacking anthers; anthers small, oblong, dorsifixed; pollen 3-colporate or 4-ruporate; pistil 1, the carpels 4–20, the styles 4–20, filiform, usually long (short in *Anthodiscus*), stigmas punctate; ovary 4–20-locular, the ovules 1 per locule, axile, bitegmic, anatropous; fruit a drupe, the epicarp sometimes coriaceous, endocarp woody, muricate, splitting into mericarps; seeds reniform; cotyledons small, hooked-inflexed, 0.04–0.1 the length of the embryo, the radicle much thickened, curved or twisted, 7–15 times wider than the cotyledons; endosperm scanty or 0.

Composition: 2 genera, 25 species.

Distribution: Tropical America, centered in the Amazon basin.

OCHNACEAE (Figure 56*a-e*).—Trees and shrubs, rarely herbs; xylem vessel perforation plates typically simple, but those of some genera with few or many bars; cortical bundles are nearly always present in the stem; leaves alternate (also opposite in *Rhytidanthera*), simple or very rarely pinnately compound, often with numerous pinnate veins extending from the midrib, mostly sharply serrate, more rarely entire, stipulate; inflorescences axillary and terminal panicles, racemes or cymes, sometimes umbelliform; flowers bisexual, the parts hypogynous; sepals 5 (3–10), imbricate, free or basally connate, sometimes 1 or 2 accrescent and wing-like in fruit (*Lophireae*), sometimes colored; petals 5 (4–12), free; stamens persistent, numerous (to ~80) or 5 or 10, in 1–5 whorls, the filaments filiform, free or sometimes connate basally, or united with staminodes into a tube (*Lavradia*); anthers linear, basifixed, dehiscent longitudinally or by a terminal pore; pollen 3-colporate, occasionally 4-rupate; pistil 1,

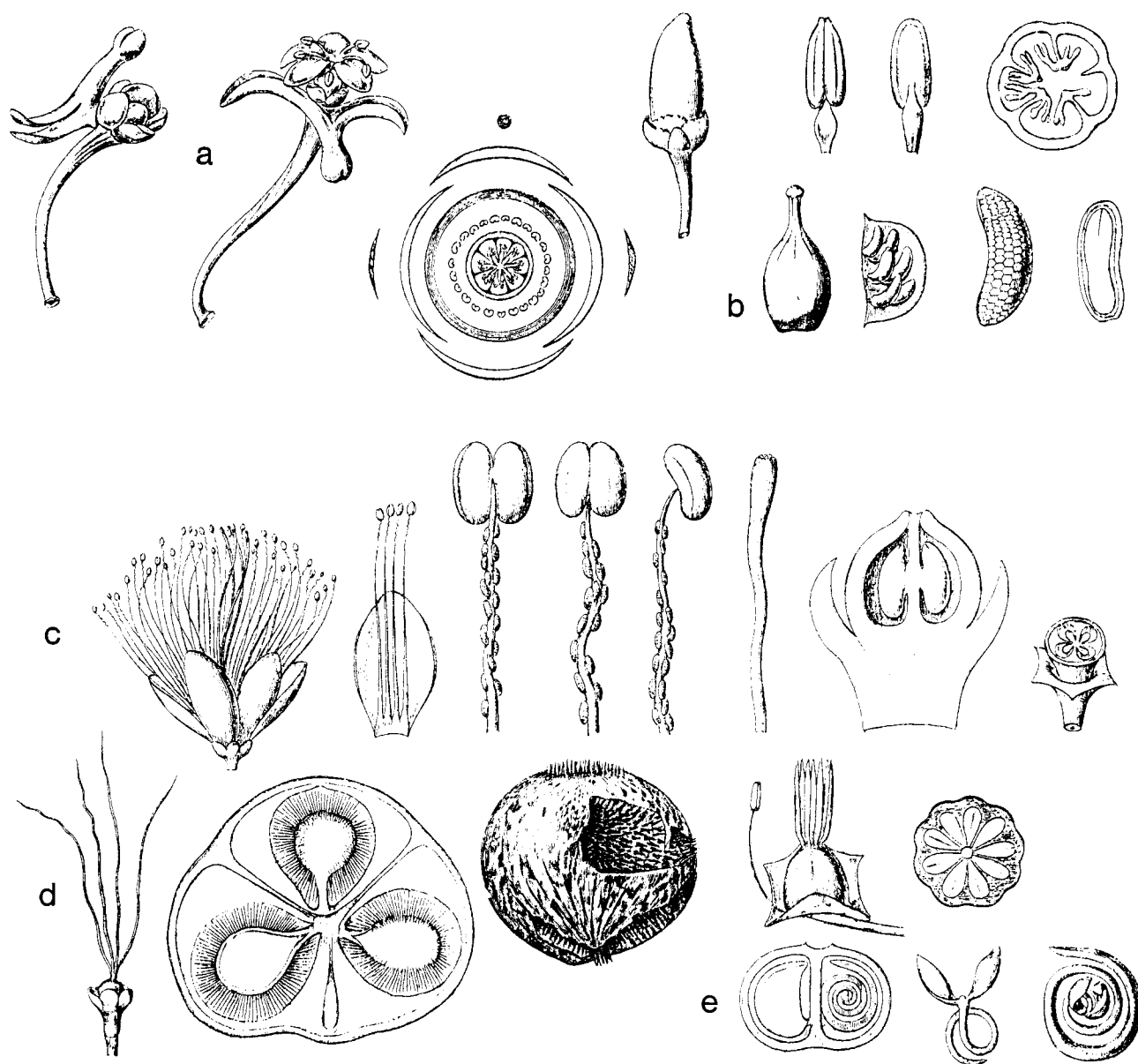


FIGURE 55.—MARCGRAVIACEAE: *a*, *Souroubea crassipes* pedicel with bud and bract, pedicel with flower and bract, *Marcgravia polyantha* floral diagram, bud, *Norantea delphiniana* views of stamen, c.s. of ovary; *b*, *N. adamantium* pistil, l.s. of ovary, seed, l.s. of same (after Martius, 1840–1906). CARYOCARACEAE: *c*, *Caryocar crenatum* flower, petal and stamens, views of stamen, 1 style, l.s. of ovary, c.s. of ovary; *d*, *C. glabrum* pistil, c.s. of semimature fruit, putamen, *Anthodiscus obovatus* pistil, calyx and one of the stamens, c.s. of ovary; *e*, l.s. of fruit, embryos (after Martius).

the carpels 2–5 (–15), the style 1, elongate, sometimes gynobasic, the stigmas apical; ovary deeply lobed or entire, 2–5 (1–15)-locular, sometimes surrounded by an annular basal disk, the ovules

1–many per locule, axile or parietal, bitegmic, tenuinucellar, anatropous or campylotropous; fruit of several drupaceous fruitlets on an enlarged, red, fleshy torus, or a berry or a septicidal

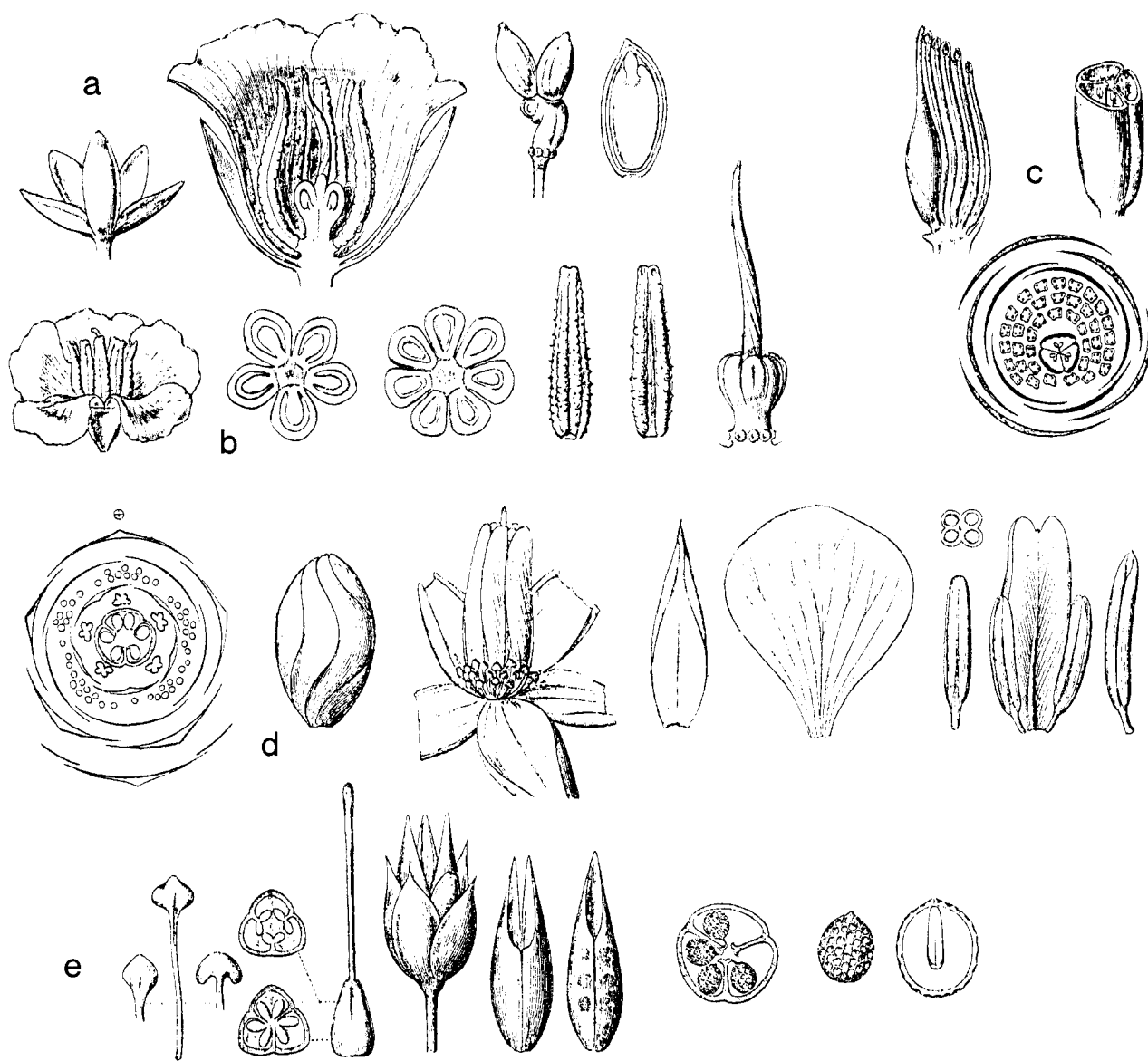


FIGURE 56.—OCHNACEAE: *a*, *Ouratea spectabilis* calyx, l.s. of flower, fruit, l.s. of same; *b*, flower, c.s. of 2 ovaries, views of stamen, pistil; *c*, *Luxemburgia nobilis* pistil and several stamens, c.s. of fruit, floral diagram; *d*, *Sauvagesia sprengelii* floral diagram, corolla in bud, calyx and internal squamulae and external processes, sepal, petal, stamen and c.s. of anther, squama and 2 stamens, another view of stamen; *e*, external processes, c.s. of ovary, pistil, dehiscent fruit, valves, c.s. of fruit, seed, l.s. of same (after Martius, 1840–1906).

capsule; seeds 1-many; embryo usually straight, in *Ochna* large, the cotyledons thick, plano-convex, 0.9 the length of the embryo, the radicle slightly invested, and endosperm 0; in *Luxemburgiae* the embryo is linear or spatulate, 0.7

the length of the endosperm, the cotyledons 0.5 the length of the embryo.

Composition: ~35 genera, ~500 species.

Distribution: Pantropical, centered in South America.

STRASBURGERIACEAE (Figure 57a).—Tree with cortical vascular bundles and large mucilage cells and passages in tissues; xylem vessel perforation plates simple and scalariform; leaves alternate, simple, remotely toothed, coriaceous, stipulate; flowers bisexual, solitary, axillary; sepals 8–10, free, unequal, spirally arranged; petals 5, free, rather fleshy; stamens 10, the filaments elongated, free; anthers large, elongated, oblong, dorsifixed; pollen 3(4)-colporate, brevicolpate; disk thick, annular, 10-lobed, surrounding the base of the ovary; pistil 1, the carpels 5, style 1, elongated, the stigma apical, capitate; ovary superior, 5-locular, the ovules 2 per locule, axile; fruit a large berry, the seeds trigonous; cotyledons thick, subelliptic, the radicle short; endosperm fleshy.

Composition: 1 genus, 1 species.

Distribution: New Caledonia.

DIEGODENDRACEAE (Figure 57b).—Shrub or small tree; xylem unknown; leaves alternate, simple, entire, pellucid-punctate, smelling of camphor when crushed, the stipules long, intrapetio- lar, coiled around the bud; inflorescence a terminal cymose panicle; flowers bisexual, actinomorphic, the parts hypogynous, fragrance of rose; sepals 5 (–6), free, imbricate, unequal; petals 5 (–6), free, large, slightly unequal; stamens very numerous (to ~434), free, the filaments elongate, filiform; anthers small, about as long as wide, basifixed; pollen tricolporate; pistil 1, the carpels 2 (–4), the style 1, elongate gynobasic, the stigma apical, punctiform; ovaries 2 (–4), the ovules 2 per carpel, basal; fruit of 1–3 dry coriaceous mericarps, $3 \times 2.5 \times 2$ cm, with very numerous verrucosities, and very numerous small peltate glands; seeds $2.5 \times 2 \times 1.2$ cm, coriaceous, smooth; cotyledons foliaceous, $2.3 \times 2.0 \times 0.3$ cm, narrowly notched for 5–6 mm basally; radicle invested, 0.7 cm long; endosperm 0.

Composition: 1 genus, 1 species.

Distribution: Madagascar.

SPHAEROSEPALACEAE (Figure 57c,d).—Trees, sometimes large, and shrubs, rich in mucilage, with extremely tenacious and fibrous bark; xylem

vessel perforation plates simple; leaves alternate, simple, entire, the stipules intrapetio- lar and caducous; inflorescences axillary and terminal umbelliform cymes arranged in a panicle, the pedicels stout; flowers bisexual; the parts hypogynous, densely streaked with short lines (? mucilaginous or resinous); sepals 4 in 2 whorls, rarely 6, free, markedly imbricate and differing in size, coriaceous; petals 4 (5–8), in 2 whorls, free, unequal, imbricate, about the size of the sepals or smaller, sometimes caducous; stamens 25–160, in 2–4 whorls, the filaments elongate, free or shortly connate, the anthers small, dorsifixed, didymous, the sacs separated by a broad glandular connective, dehiscing longitudinally; pollen 3–4 (–6)-colpor(oid)ate, finely echinate; disk large or rarely absent (*Rhopalocarpus thouarsianus*), cupular, below and surrounding the base of the ovary; a small gynophore present; pistil 1, the carpels 2–4 (–5), the style 1, elongate, rarely gynobasic (*Dialyceras*), slightly geniculate, the stigma capitate or very shortly 3–4-lobed; ovary 2–4 (–5)-locular and lobed or of 4 separate parts (*Dialyceras*), the ovules 2–9 per locule, basal or basal-axile, bitegmic, anatropous; fruit a nut or dryish berry, some locules aborting, or a schizocarp of horn-shaped parts, the seeds mostly 1 per locule, large, initially enclosed in a translucent glutinous mass; embryo straight, filling most of the seed, the cotyledons separate from one another (right and left), thin, undulate, foliaceous, basally cordate, bilobed apically, the lobes lobulate, sometimes laciniate, 0.65–0.8 the length of the embryo, 4–9 times wider than the terete radicle; endosperm moderate, sometimes ruminant.

Composition: 2 genera, 14 species.

Distribution: Madagascar.

SCYTOPETALACEAE (Figure 58a,b).—Trees and shrubs; xylem vessel perforation plates simple or with few bars (to 12); leaves alternate, simple, entire or dentate, often distichous, exstipulate; inflorescence terminal panicles or axillary racemes, or umbelliform or racemiform cauliflorous fascicles; flowers bisexual; calyx short, flatish or cupular, the margin entire or 3–4-

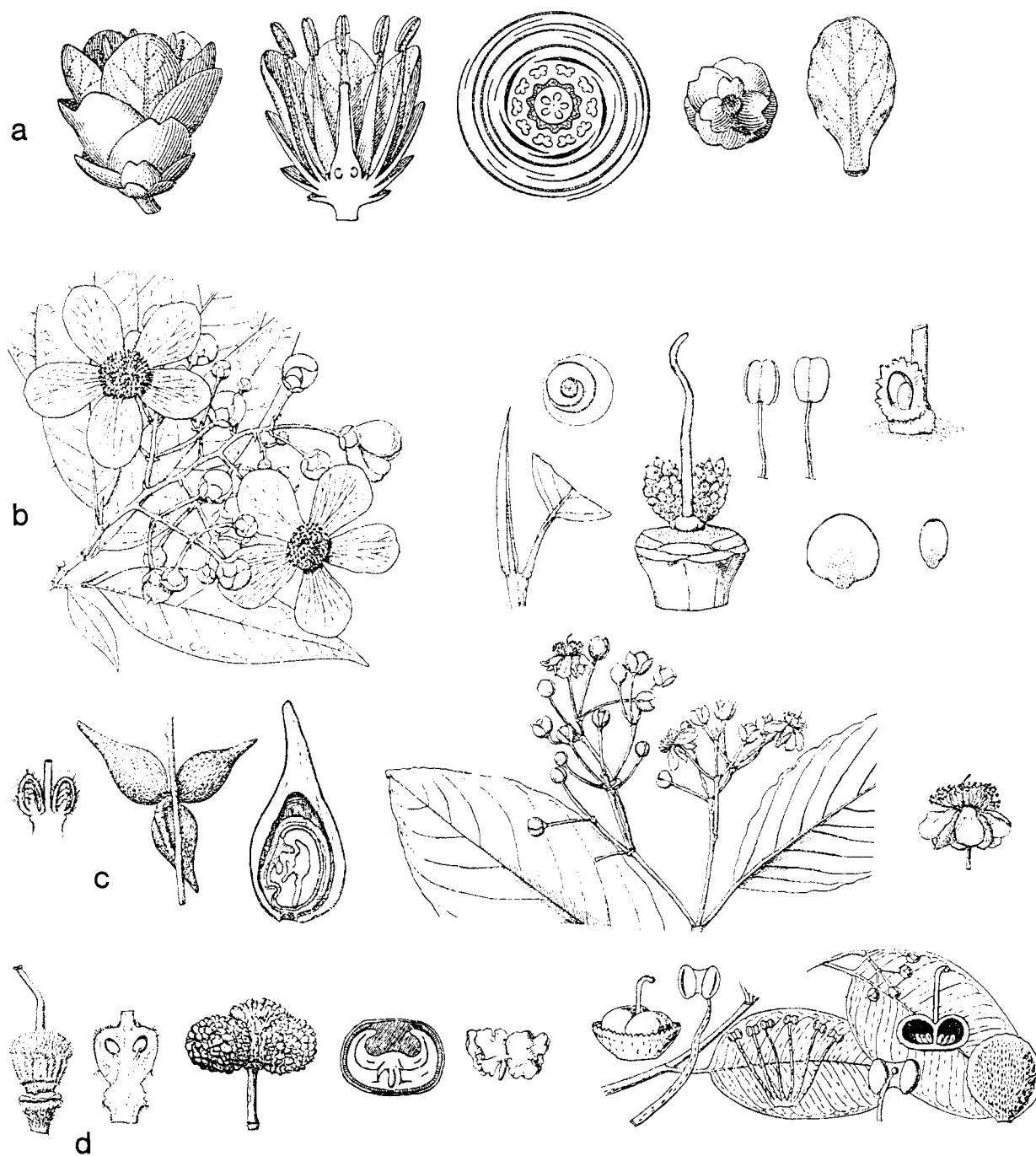


FIGURE 57.—STRASBURGERIACEAE: *a*, *Strasburgeria calliantha* flower, l.s. of same, floral diagram, calyx from below, petal (after Engler). DIEGODENDRACEAE: *b*, *Diegodendron humberti* flowering branch, stipules and c.s. of a pair of stipules (after Capuron, 1963a). SPHAEROSEPALACEAE: *c*, *Dialyceras parvifolium* 2 carpels opened to show ovules, fruit, mericarp opened showing l.s. of seed, *Rhopalocarpus excelsus* flowering twig, flower; *d*, pistil, l.s. of ovary, *R. thouarianus* fruit, l.s. of a fruitlet, embryo, *R. alternifolius* pistil and disk, stamen, group of stamens, dorsal view of anther, l.s. of ovary, petal (after Capuron, 1963b; Hutchinson, 1973).

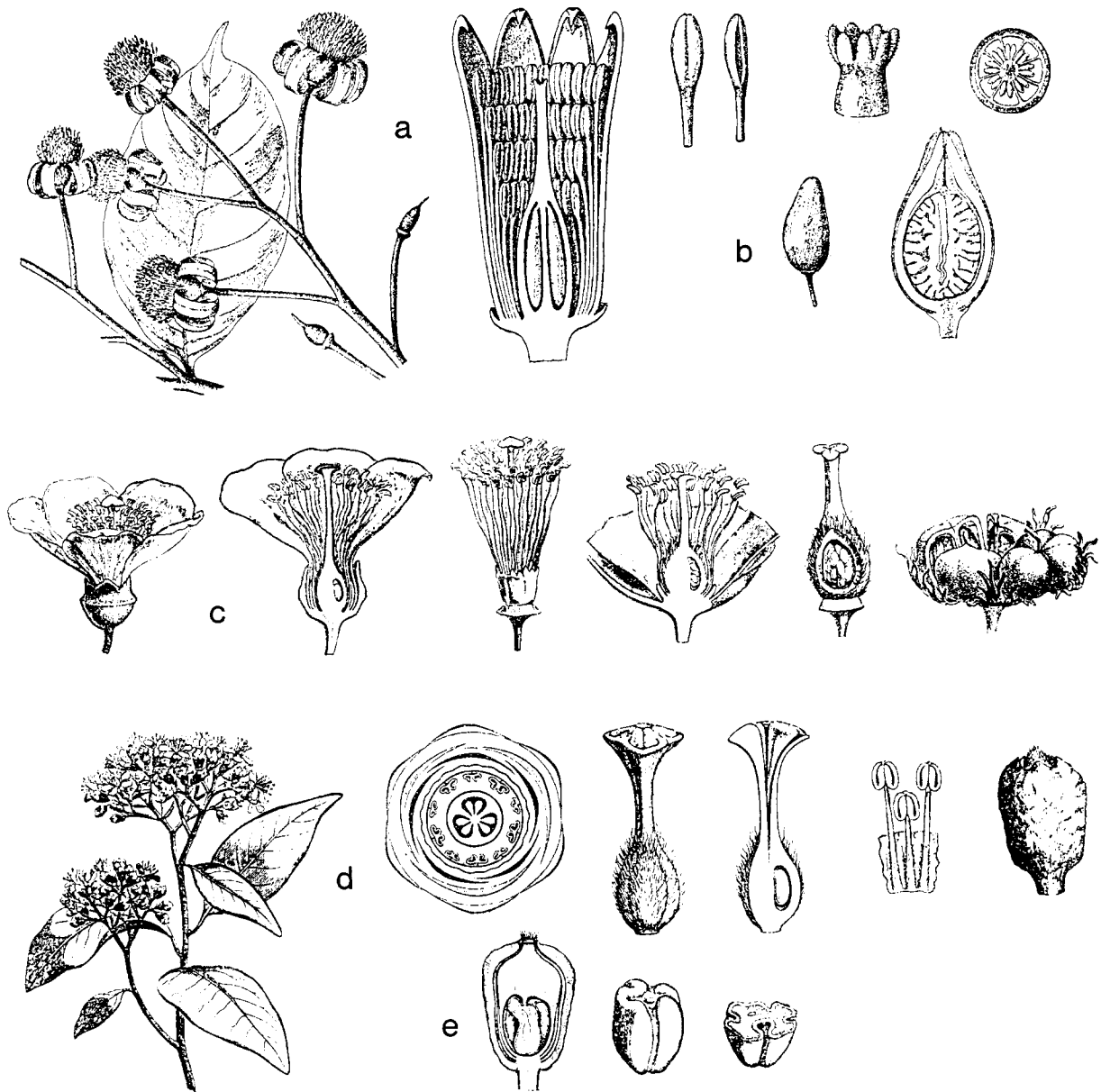


FIGURE 58.—SCYTOPELTALACEAE: *a*, *Scytoceltum klaineum* twigs with flowers and young fruit, l.s. of bud, views of anther, stigmas, c.s. of ovary; *b*, fruit, l.s. of same showing the embryo and endosperm of the seed (after Engler; Pierre). SARCOLAENACEAE: *c*, *Sarcolaena multiflora* flower, l.s. same, same without the perianth, *Schizolaena rosea* l.s. of flower with part of corolla cut off, pistil with 1 ovary locule opened, 2 fruits one dehiscent; *d*, *Leptolaena multiflora* flowering branch, floral diagram, pistil, l.s. of same, part of disk and androecium, fruit; *e*, l.s. of fruit, seed, c.s. of same (after Baillon, 1866–1895).

toothed; petals 3–16, sometimes basally connate, valvate; stamens numerous (~80), rarely 10, sometimes on an annular disk, sometimes shortly connate, the filaments filiform; anthers about as

long as wide, basifixed, dehiscent by a pore or slit; pollen 3-colpate or 3-colpor(oid)ate; pistil 1, the carpels 3–8, the style 1, stigma small, apical; ovary superior, 3–8-locular, the ovules 2–several

per locule, axile, subapical, unitegmic, crassinucellar (?), anatropous; fruit a loculicidal woody capsule, rarely a 1-seeded drupe; seeds sometimes long-haired; embryo 0.8 the length of the endosperm; cotyledons broad and thin, 0.5 the length of the embryo; endosperm copious, often ruminate.

Composition: 5 genera, 30 species.

Distribution: Tropical western Africa.

SARCOLAENACEAE (Figure 58*c-e*).—Shrubs and trees; xylem vessel perforation plates simple; leaves alternate, simple, entire, stipules present, often large; inflorescences cymes or panicles, or the flowers solitary or paired; flowers bisexual, fairly large, often subtended by bracts; sepals 3–5, free, sometimes unequal, imbricate; petals 5–6, free; stamens numerous (to ~50), rarely 5–10, the filaments filiform, inserted on a disk, free or sometimes shortly connate or in 5 bundles; staminodes external to the stamens; anthers oblongish, slightly longer than wide, basifixed or dorsifixed, dehiscent longitudinally; pollen 3-(demi)colporate; pistil 1, the carpels 3–5, style 1, the stigmas 3–5, apical; ovary 3–5-locular, the ovules 2-several per locule, axile; fruit a loculicidal capsule or indehiscent and 1-seeded; embryo 0.5 the length of the endosperm; cotyledons foliaceous, plane or undulate, twice as wide as the radicle, 0.5 the length of the embryo; endosperm copious, fleshy or corneous.

Composition: 8 genera, 40 species.

Distribution: Madagascar.

EBENALES

Trees and shrubs; xylem vessel perforation plates simple, rarely also a few scalariform with few bars; laticifers sometimes present; leaves alternate, rarely opposite, simple, entire, toothed in only 1 species, usually exstipulate; flowers bisexual or unisexual; sepals 3–8 (12), connate; petals 3–8, connate; stamens 3–50 (~120?), usually 2–4 times the number of corolla lobes, one series sometimes staminodal, hypogynous or adnate to the corolla, the filaments free, rarely connate; anthers adnate, basifixed or dorsifixed;

pollen 3–4 (–6)-colporate; pistil 1, the carpels 2–16, styles 1–8, free or connate, the stigmas apical; ovary superior, 2–16-locular, the ovules 1 (2) per locule, axile; fruit a berry, rarely a capsule; embryo straight, usually moderate-sized; endosperm copious to absent.

Distribution: Pantropical, mainly in rain forest, few in temperate and dry regions.

Chemistry: Kubitzki mentions the occurrence of protoaporphine and aporphine in some Ebenales; Gibbs does not mention them. The Ebenaceae are unique in having a + Juglone test and naphthaquinones and other naphthalene derivatives. The Sapotaceae differ in having pyrrolizidine alkaloids and *d*-quercitol.

EBENACEAE (Figure 59*a,b*).—Trees and shrubs; xylem vessel perforation plates simple; hairs occasionally 2-shanked; leaves alternate, rarely opposite or whorled, simple, entire, exstipulate; inflorescences axillary or rarely cauliflorous cymes or the flowers solitary; flowers mostly unisexual, the plants often dioecious, sometimes polygamous; sepals 3–7, connate; petals 3–7, connate, usually contorted and imbricate, rarely valvate; stamens 3–50 (~120?), usually 2–4 times the number of corolla lobes, rarely equal in number and alternate with them, hypogynous or inserted on the corolla, the filaments free or connate in pairs; anthers elongated, adnate or basifixed, dehiscent longitudinally, more rarely by apical pores, apiculate; pollen 3-colporate; pistil 1, the carpels 2–16, styles 2–8, free or connate part way, the stigmas apical; ovary superior, 2–16-locular, sometimes incompletely so, the ovules 1 (2) per locule, axile-subapical, bitegmic, tenuinucellar, anatropous; fruit a berry, rarely tardily dehiscent apically by valves; embryo straight, 0.5–0.6 the length of the endosperm; cotyledons 2–3 times wider than the radicle, 0.5–0.7 the length of the embryo; endosperm copious, very hard.

Composition: 2 genera, 500 species.

Distribution: Tropical and subtropical, few temperate; centered in lowland rain forest of the East Indies, extending to India, Japan, and Australia; next most abundant in Africa and then

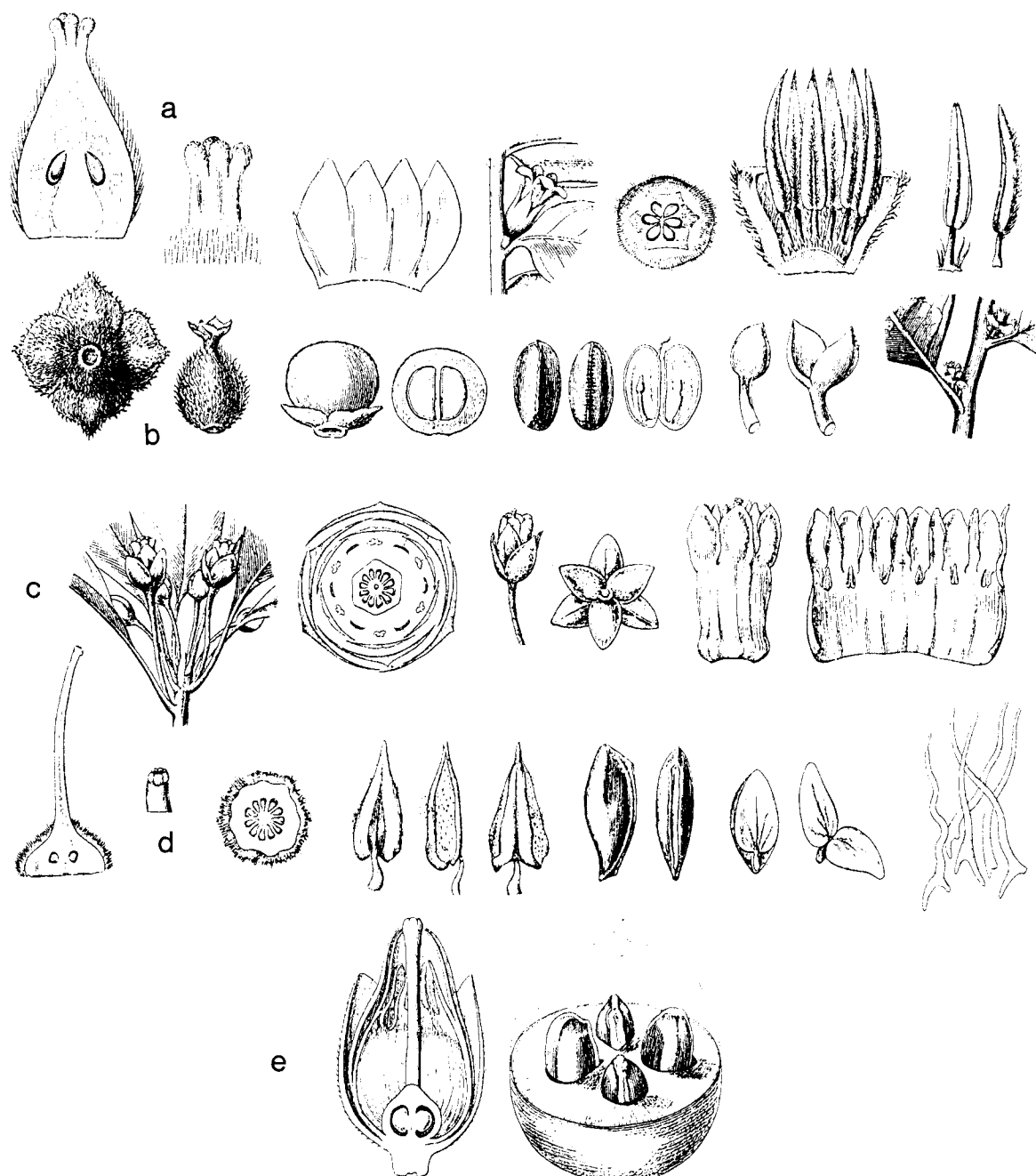


FIGURE 59.—EBENACEAE: *a*, *Diospyros coccolobaefolia* l.s. of pistil, stigma, corolla laid open showing staminodes, *D. sericea* flower in axil of leaf, c.s. of ovary, *D. guianensis* part of corolla with stamens, views of stamen; *b*, calyx, corolla, fruit, l.s. of same, views of seed, l.s. of same, embryo, same with cotyledons laid open, axillary flowers (after Martius, 1840–1906). SAPOTACEAE: *c*, *Manilkara zapota* axillary flowers, floral diagram, flower, calyx, corolla, same laid open showing insertion of stamens and broad staminodes; *d*, l.s. of pistil, stigma, c.s. of ovary, views of stamen, views of seed showing long hilum, l.s. of seed without testa, embryo laid open, hairs from pistil; *e*, *Lucuma caimito* l.s. of bud, c.s. of fruit (after Martius, 1840–1906).

America; eastern United States; southwestern Asia.

SAPOTACEAE (Figure 59*c-e*).—Trees and shrubs with laticiferous canals in the pith, cortex, and leaves; xylem vessel perforation plates simple, rarely also occasional scalariform plates with 1–7 bars; hairs commonly 2-shanked; leaves alternate, very rarely subopposite or verticillate, simple, entire, very rarely toothed (*Chrysophyllum imperiale*), coriaceous, usually exstipulate; inflorescences axillary or cauliflorous cymose fascicles, or the flower solitary; flowers bisexual, more rarely the plants polygamous; sepals 4–8 (12), sometimes in 2 series or spirally arranged, shortly connate; petals 4–8 in 1 or 2 series, connate, imbricate; stamens 4–24, epipetalous, rarely also connate in a tube (*Aulandra*), 1–3 times the number of petals, in 1–3 series, if uniseriate then opposite the petals, one series often staminodal and petaloid; anthers about as long as wide or elongated, basifixed or dorsifixed, commonly extrorse; pollen 3–4 (–6)-colporate—slightly ruplicate; hypogynous annular disk rarely present; pistil 1, the carpels 4–12 (2), style 1, elongated or short, the stigma(s) apical; ovary superior 4–12 (2)-locular, the ovules 1 per locule, axile, unitegmic, the integument thick, tenuinucellar, anatropous or suborthotropous; fruit a berry, rarely a capsule; embryo straight, as long as the endosperm; cotyledons thin, or thick and plano-convex, rarely conferruminate, 4.5–7.0 times wider than the radicle, 0.5–0.9 the length of the embryo; endosperm moderate or 0, fleshy or hard.

Composition: ~50 genera, 800 species.

Distribution: Pantropical, mainly in lowland and lower montane rain forest, few temperate.

STYRACALES

Trees and shrubs; xylem vessel perforation plates scalariform and simple, with fewer than 20 bars; laticifers sometimes present; leaves alternate, simple, entire or toothed, the indument commonly stellate or lepidote, exstipulate; flowers bisexual, rarely unisexual; sepals 4–10, con-

nate, the lobes short; petals 4–10, free or basally connate; stamens 4–10 (–32), the filaments free or connate, hypogynous or inserted on the corolla, the anthers linear, basifixed or adnate; pollen 3–4 (2–5)-colporate or -porate; pistil 1, the carpels 2–5, style 1, the stigma(s) apical, rarely decurrent ventrally; ovary superior to inferior, 1–5-locular, the ovules 1–several per locule, axile or apical; fruit nut-like, sometimes winged, or a loculicidal capsule or drupe; embryo moderate-sized; endosperm usually copious.

Distribution: Mostly in eastern Asia, the United States, tropical South America, and tropical Africa.

Chemistry: Huber considers Styracaceae and Symplocaceae related to his Cornales, which are derived from relatives of Theaceae. *Alangium* has isoquinoline alkaloids of the emetine group and certain pyridine alkaloid, not known to occur in Cornales. The former occur principally in Rubiaceae, but also in Icacinaceae; the latter occurs in various families.

STYRACACEAE (Figure 60*a,b*).—Trees and shrubs; xylem vessel perforation plates scalariform with fewer than 20 bars, some simple perforations in *Bruinsmia*; leaves alternate, simple, usually entire, sometimes toothed, the indument mostly stellate or lepidote, exstipulate; inflorescences axillary or terminal, mostly racemes or panicles, sometimes cymes, rarely the flowers solitary; flowers bisexual, rarely the plants polygamodioecious; sepals 4–5 (–7), connate, the lobes valvate or the calyx open in bud, often truncate; petals 4–5 (–7), mostly basally connate, rarely free?; stamens 4–10 (–14), alternate with the corolla lobes if equal to them in number, the filaments usually connate and often inserted basally on the corolla, rarely hypogynous; anthers usually elongated, rarely round, basifixed, sometimes the connective produced apically; pollen 3-colpor(oid)ate (\pm constricti-colpate); pistil 1, the carpels 3–5, style 1, the stigma apical, punctiform or 3–5-lobed; ovary superior, semi-inferior or inferior, 3–5-locular, often unilocular above, sometimes at length entirely unilocular, the ovules 1 to several per locule, axile, 1–2-tegmic,

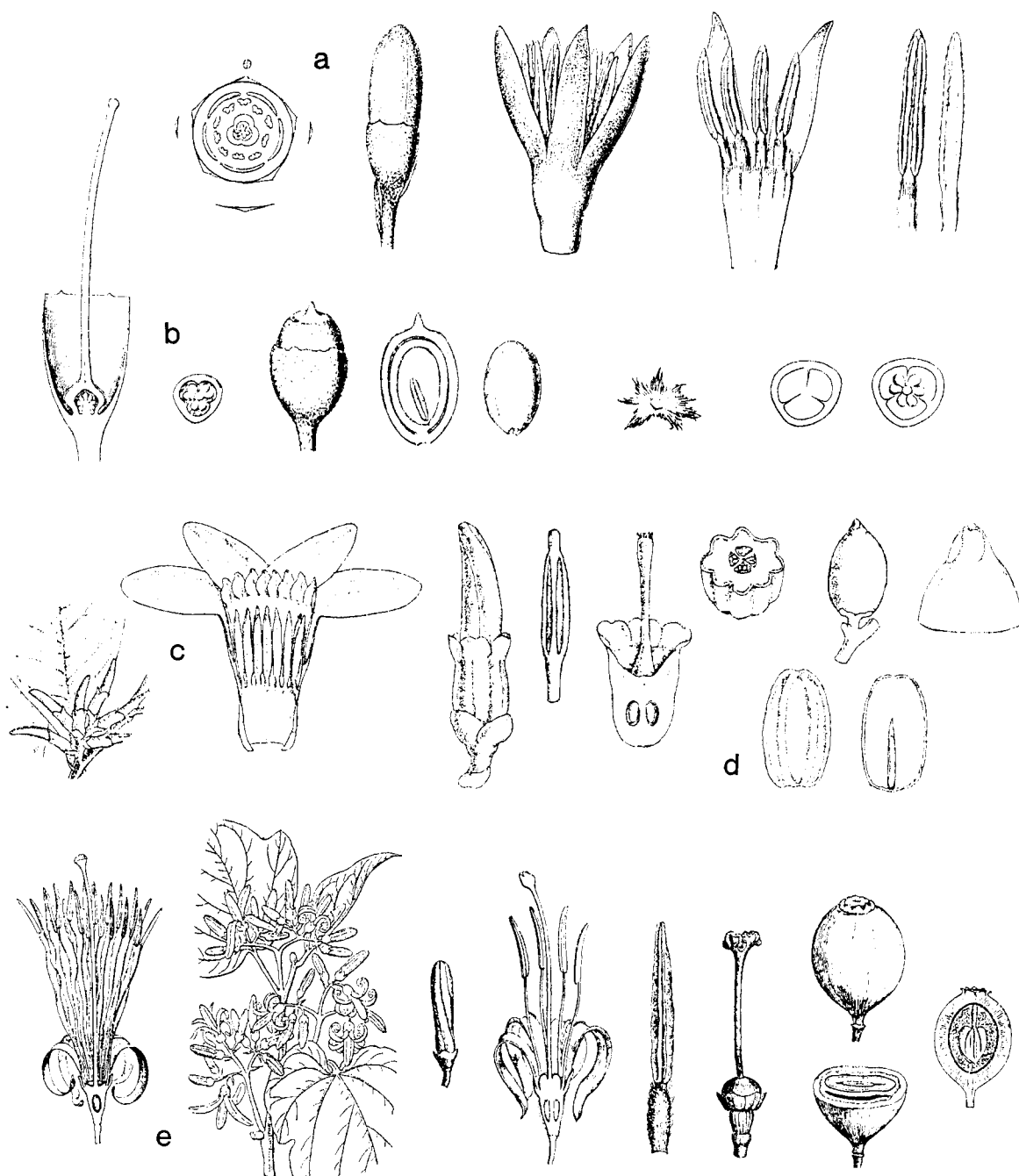


FIGURE 60.—STYRACACEAE: *a*, *Styrax martii* floral diagram, bud, flower (calyx removed), part of corolla laid open showing insertion of stamens, views of stamen; *b*, l.s. of pistil, c.s. of ovary, fruit and calyx, l.s. of fruit showing the embryo in copious endosperm, seed, *S. leprosum* indument scale from leaf, c.s. of ovary (after Martius, 1840–1906). LISSOCARPACEAE: *c*, *Lissocarpa benthami* axillary inflorescence, corolla laid open, bud, anther, l.s. of ovary and calyx, c.s. of ovary, fruit, apex of fruit showing the persistent calyx lobes; *d*, seed, l.s. of same showing the embryo (after Oliver). ALANGIACEAE: *e*, *Alangium decapetalum* l.s. of flower, *A. begoniifolium* twig with axillary inflorescences, bud, l.s. of flower, stamen, pistil, fruit and c.s. of same, *A. salviifolium* l.s. of fruit (after Baillon, 1866–1895; Wangerin).

tenuinucellar, anatropous or semi-anatropous; fruit nut-like, sometimes winged, or a loculicidal capsule, rarely a drupe, the seeds 1 or few, rarely numerous (*Huodendron*, *Alniphyllum*); embryo straight or slightly curved, 0.8 the length of the endosperm; cotyledons thin, (1) 2–5 times wider than the radicle, (0.2) 0.5–0.8 the length of the embryo; endosperm copious, fleshy.

Composition: 12 genera, 180 species.

Distribution: Japan to southeastern Asia, western East Indies; eastern and western United States to the northern $\frac{3}{5}$ of South America, West Indies; one species in the Mediterranean region.

LISSOCARPACEAE (Figure 60*c,d*).—Small trees; xylem vessel perforation plates simple and scalariform; leaves alternate, simple, entire, exstipulate; inflorescences axillary, cymose; flowers bisexual; sepals 4, connate, imbricate; petals 4, connate, the lobes contorted in bud; corona of 8 teeth at the apex of the corolla-tube; stamens 8, in one series, inserted on the corolla-tube, the filaments short; anthers linear, basifixed, the connective produced apically; pollen 3-porate; pistil 1, the carpels 4, style 1, the stigma apical, simple or indistinctly 4-lobed; ovary inferior, 4-locular, the ovules 2 per locule, axile-subapical; fruit a drupe, the seeds 1–2; embryo subterete, straight, 0.5 the length of the endosperm; endosperm copious, horny.

Composition: 1 genus, 2 species.

Distribution: Tropical South America.

ALANGIACEAE (Figure 60*e*).—Trees and shrubs, rarely a liana, rarely spiny; xylem vessel perforation plates scalariform, typically with fewer than 10 bars, occasionally more, some species with simple perforations; laticifers present in flowers, fruit and leaves; leaves alternate, simple entire or with 1–3 large teeth or with small lobes, exstipulate; inflorescences axillary, cymose-paniculate; flowers bisexual, the plants rarely dioecious or polygamous (*Alangium griseoloides*); sepals 4–10, connate, the calyx truncate or short-toothed; petals 4–10, linear, valvate, free or basally connate; stamens 4–10 (–32), alternipetalous when equal to the number of petals, free or slightly connate basally, the filaments sometimes

inserted on the base of the petals; anthers linear, adnate with connective between the sacs or basifixed; pollen 3–4 (2–5)-colporate, colpoidorate or porate; disk epigynous; pistil 1, the carpels 2–3, style 1, the stigma punctiform or 2–3-lobed, apical or decurrent ventrally; ovary inferior 1 (–3)-locular, sometimes 1-locular at the apex and 2–3-locular at the base, the ovules 1 per locule, apical, unitegmic, crassinucellar, anatropous; fruit a drupe, the seed 1; embryo straight, 0.9 the length of the endosperm; cotyledons thin, foliaceous, 3–6 times wider than the radicle, 0.6–0.9 the length of the embryo; endosperm copious or moderate, fleshy, ruminate, or friable.

Composition: 1 genus, 17 species.

Distribution: Japan, Korea, China to India, Malaya, the East Indies and northeastern Australia; tropical Africa, Madagascar.

VIOLALES

Trees, shrubs, and herbs, sometimes climbing; xylem vessel perforation plates scalariform with many or few bars, simple, or both; leaves usually alternate, simple, rarely compound, entire, toothed, lobed or divided, sometimes with extrafloral nectaries, sometimes distichous, usually stipulate; flowers bisexual or unisexual, actinomorphic or rarely zygomorphic, the parts hypogynous, perigynous or rarely epigynous; perianth rarely not differentiated into sepals and petals; sepals 3–5 (0, 2–15), free or connate; petals 3–5 (0–15), rarely 2–4-seriate, very rarely spirally arranged, very rarely transitional to stamens, free, more rarely connate, sometimes inserted on the calyx, sometimes a corona present; stamens usually numerous, to ~300, or 10–1, in 1–5 series; staminodes sometimes present; filaments free or connate, sometimes in bundles or rarely in a column, hypogynous or inserted on the calyx, more rarely on the corolla; anthers dorsifixed, basifixed or rarely adnate, very rarely connate, sometimes the connective produced apically; pollen usually 3 (2–12)-colporate, rarely 3 (7–9)-colpate, very rarely 2-pantoporate; glandular disk often present; pistil 1, the carpels 3

(2–10), styles 1, 3 (–10), very rarely repeatedly branched, the stigma(s) apical, very rarely decurrent ventrally, rarely sessile; ovary superior, rarely semi-inferior or inferior, usually 1-locular, rarely 2- or 4-locular, the ovules usually numerous, rarely only 1, parietal, rarely axile or apical; fruit a berry or loculicidal, rarely septicidal capsule, rarely a drupe, samara or nutlet; seeds usually numerous, rarely only 1, often arillate, rarely winged; embryo straight, often nearly as long as the endosperm; endosperm usually copious, rarely scanty or absent.

Distribution: Mostly pantropical and -subtropical, few temperate, in various habitats.

Chemistry: The order is not aromatic, only very few terpenoids are recorded. Saponins are not characteristic of the order. Coumarins are absent or nearly absent. The order is not alkaloid-rich. Flacourtiaceae have fatty-acids of the chaulmoogric series in their seed-fats. Myrosin-cells containing isothiocyanate glycosides and glucotropaeolin are said to be present in Caricaceae.

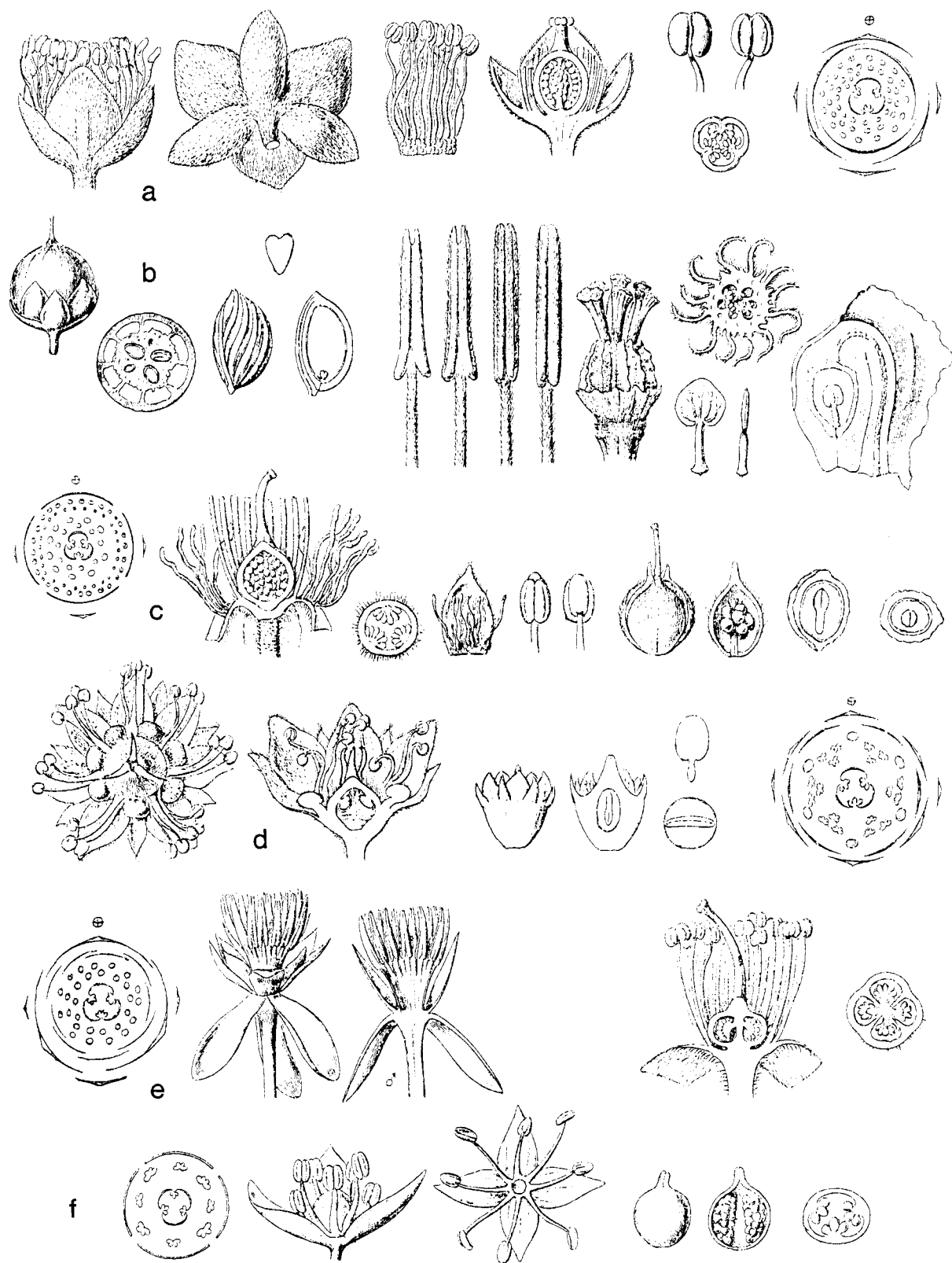
FLACOURTIACEAE (Figure 61*a–f*).—Trees and shrubs, rarely climbing; xylem vessel perforation plates usually simple, but some species wholly scalariform; leaves alternate, very rarely opposite, simple, often distichous and coriaceous, serrate or entire, sometimes pellucid-dotted or lined, stipulate, very rarely exstipulate (*Abatia*); inflorescences axillary, terminal or below the leaves, racemes, cymes or rarely heads or sometimes catkin-like, or the flowers solitary, rarely epiphyllous or cauliflorous; flowers bisexual or the plants polygamous, monoecious or dioecious, the parts hypogynous, perigynous or rarely epigynous; perianth sometimes not clearly differentiated into sepals and petals, sometimes accrescent; sepals 6–3 (2–15), free or connate, imbricate or open in bud or nearly valvate; petals 8–3 (0–15), free, sometimes 2-seriate, those of the inner series smaller, sometimes 2–3 times as many as the sepals, rarely spirally arranged, sometimes gradually transitional to stamens, sometimes with an opposite basal glandular scale, or corona (from staminodes?) extra- or intrastam-

inal; stamens usually numerous (to 100+), rarely only 1, in several or 1 series, the filaments elongate, free or connate in antepetalous bundles or all connate into a tube, or rarely united into a column; staminodes sometimes present; anthers linear to about as long as wide, dorsifixed or basifixed, sometimes the connective produced apically; pollen 3 (–6)-colporate; annular disk, glands or scales present between the corolla and stamens or between the stamens and pistil; pistil 1, the carpels 2–10, the styles 1–10, free or connate, rarely repeatedly branched and with numerous stigmas (*Dendrostigma*, *Mayna*), the stigmas sometimes apical; ovary superior, rarely semi-inferior or inferior, usually unilocular, rarely 2- or 4-locular, rarely imperfectly 2–6-locular, the placentas 2–10, usually parietal, rarely axile or apical, the ovules usually numerous, sometimes only 1 per placenta, bitegmic, crassinucellar, anatropous, semi-anatropous, or orthotropous; fruit usually a berry, sometimes a loculicidal capsule, rarely a drupe or samara, sometimes densely prickly or spiny; seeds numerous to 1, rarely winged or with sarcotesta, rarely covered with long hairs (*Calantica*), often arillate; embryo straight, usually large, 0.9 the length of the endosperm, rarely small; cotyledons thin, 6–20 times wider than the radicle, rarely terete, usually 0.8–0.9 the length of the embryo, rarely shorter than the radicle (*Streptothamnus*); endosperm copious or moderate, rarely scanty, fleshy.

Composition: ~90 genera, ~1200 species.

Distribution: Mostly tropical and subtropical, few temperate; tropical America, southern $\frac{2}{3}$ of Africa, Arabia, India to southern China, the East Indies and northeastern Australia.

LACISTEMATACEAE (Figure 62*a–d*).—Shrubs and small trees; xylem vessel perforation plates scalariform, often with more than 20 bars, vessel elements very long (1.6 mm.); leaves simple, alternate, entire or toothed, distichous, stipulate; inflorescences often clustered, axillary dense spikes or looser racemes; flowers minute, bisexual or the plants polygamous; sepals 4–6 or 0, unequal; petals 0; stamen 1, the filament relatively long, the anther small, about as long as



wide, the anther sacs separate, sometimes distant, basifixed or adnate, dehiscing longitudinally or transversely; pollen 3-colporate; disk cupular, the stamen and pistil inserted upon it; pistil 1, the carpels 3 (2), the style 1, sometimes 0, the stigmas 3 (2), slightly elongate; ovary superior, the ovules 1–2 per placenta, parietal, bitegmic, crassinucellar, anatropous; fruit a loculicidal often fleshy capsule, the seeds 1 (–3) with aril (?) or easily removed outer testa; embryo straight, 0.9 the length of the endosperm, the cotyledons foliaceous, 0.4–0.6 the length of the embryo, 5.5–6.0 times the width of the terete radicle; endosperm (?perisperm) copious, fleshy.

Composition: 2 genera, ~25 species.

Distribution: Tropical America from Mexico to the northeastern half of South America.

PASSIFLORACEAE (Figure 62*e*).—Shrubs, herbaceous climbers with axillary tendrils, rarely trees; xylem vessel perforation plates simple, rarely also scalariform(?); leaves alternate, simple, entire or lobed, rarely compound, the petiole often with stalked glands, stipulate, rarely exstipulate; inflorescences axillary cymes or racemes or the flowers solitary, rarely the middle flower replaced by a hook; flowers bisexual or the plants monoecious or dioecious; sepals 5 (3–8), free or shortly connate, often petaloid; petals 5 (0, 3–8), free or shortly connate; corona of 1 or more series of thread-like filaments or scales or annular; stamens 5 (3–10), the filaments shortly con-

nate or in bundles, sometimes inserted on a gynophore; sometimes 5 staminodes present; anthers oblong, dorsifixed; pollen 3–12-colporate; nectar is secreted at the base of the androgynophore; pistil 1, the carpels 3 (4–5), the styles 3 (4–5), free or connate into 1, the stigmas apical, often capitate; ovary superior, unilocular, the ovules usually numerous, rarely only 3, parietal, rarely apical, bitegmic, crassinucellar, anatropous or orthotropous; fruit a berry or loculicidal capsule; seeds with pitted testa surrounded by fleshy aril; embryo straight, 0.85–0.9 the length of the endosperm; cotyledons thin, 3–5.5 times wider than the radicle, 0.6–0.7 the length of the embryo; endosperm moderate, fleshy.

Composition: 12 genera, ~600 species.

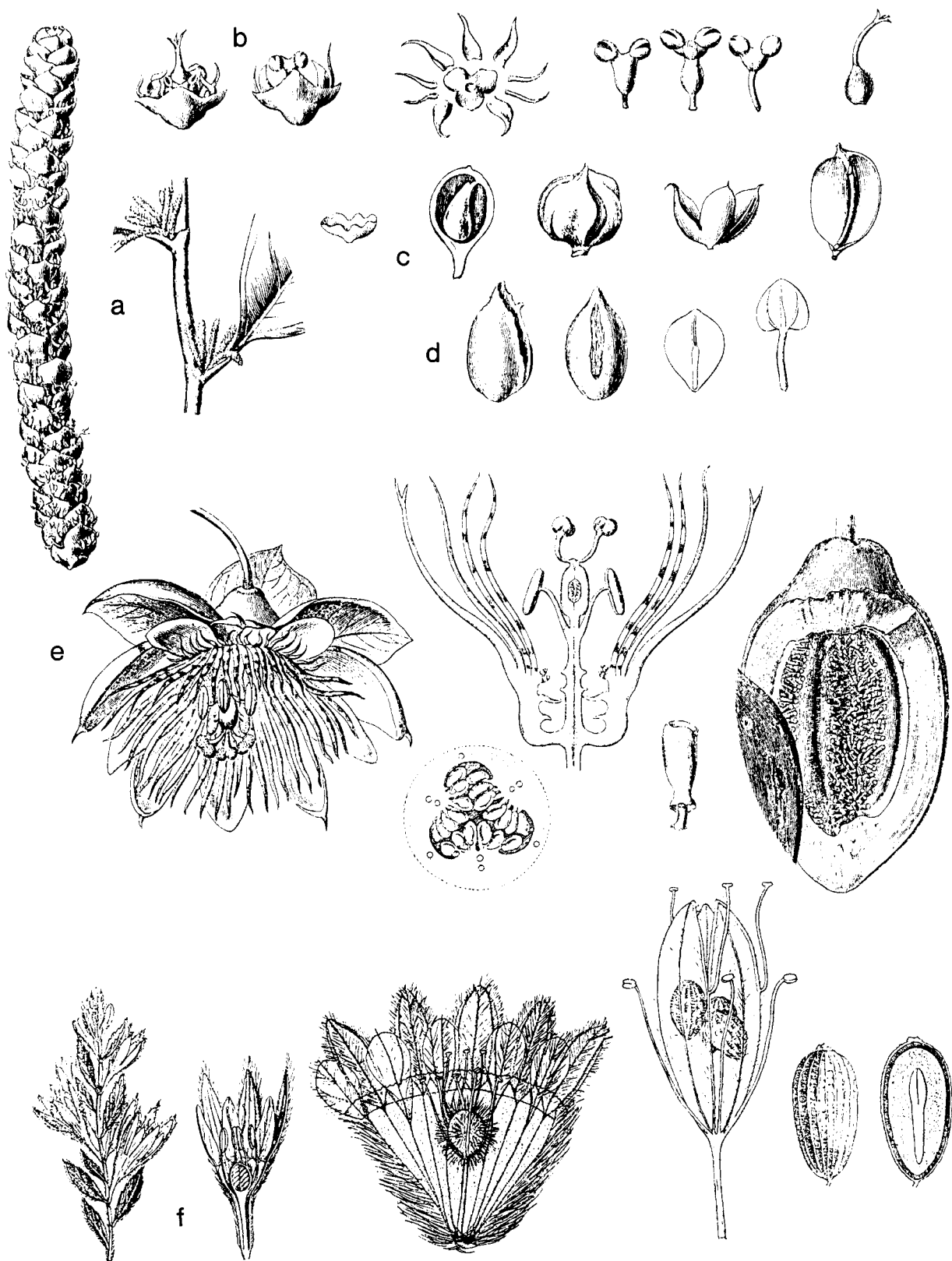
Distribution: Chiefly tropical and subtropical, few temperate; centered in America and Africa; few species from northeastern India to the East Indies, northern Australia, New Zealand, and Madagascar.

MALESHERBIACEAE (Figure 62*f*).—Subshrubs and herbs; xylem vessel perforation plates mostly simple, scalariform plates with a few bars also present; leaves alternate, simple, entire, toothed or pinnatifid, exstipulate; inflorescences axillary or terminal racemes, panicles or cymes, or the flowers solitary; flowers bisexual; calyx-tube long, the lobes 5, short; petals 5, separate, inserted on the calyx-tube; corona denticulate or membranous, at the throat of the calyx-tube; stamens 5, the filaments filiform, inserted on the gynophore immediately below the ovary; anthers oblong, dorsifixed; pollen 3-colporate; pistil 1, the carpels 3 (4), the styles 3 (4), distant, inserted below the apex of the ovary, filiform, free, the stigmas apical, sometimes capitate; ovary superior, stipitate, unilocular, the ovules numerous, parietal; fruit a membranous capsule, loculicidal from the apex to the middle; seeds pitted, exarillate; embryo straight, 0.7–0.8 the length of the endosperm; cotyledons twice as wide as the radicle, 0.4–0.5 the length of the embryo; endosperm copious, fleshy, dotted.

Composition: 1 genus, 25 species.

Distribution: Dry habitats in the Andes of

FIGURE 61.—FLACOURTIACEAE: *a*, *Banara brasiliensis* flower, calyx, stamens and sepal, l.s. of flower, views of anther and c.s. of ovary, floral diagram; *b*, *B. guianensis* fruit, c.s. of same, seed, l.s. of same showing minute embryo and embryo enlarged, *Carpotroche brasiliensis* views of stamens, pistil, c.s. of ovary and views of embryo, l.s. of seed with large aril; *c*, *Abatia tomentosa* floral diagram, l.s. of flower showing ovules, corona and filaments (anthers removed), c.s. of ovary, sepal with coronal filaments, views of anther, dehiscent fruit, valve of fruit, l.s. and c.s. of seed; *d*, *Homalium pedicellatum* flower, l.s. of same, *H. racoubea* fruit, l.s. of same, c.s. of seed, embryo, floral diagram; *e*, *Oncoba latifolia* floral diagram, ♂ flower, l.s. of same, *Prockia crucis* l.s. of flower, c.s. of ovary; *f*, *Aphaerema spicata* floral diagram, 2 views of flowers, pistil, l.s. of same, c.s. of ovary (after Martius, 1840–1906).



southern Peru, northern Chile and western Argentina.

TURNERACEAE (Figure 63*a,b*).—Shrubs, herbs, and trees; xylem vessel perforation plates mostly simple, occasionally also scalariform with numerous bars; leaves alternate, simple, sometimes lobed, dentate, the teeth sometimes glandular, often with a pair of glands at the base of the blade, stipulate or exstipulate; inflorescences axillary racemes or cymes or the flowers solitary; flowers bisexual; sepals 5, connate, rarely free; petals 5, separate, inserted on the calyx-tube, sometimes with a scale attached basally on the ventral surface, or with a corona; stamens 5, the filaments inserted on the calyx-tube; anthers as long as wide or elongate, dorsifixed near the base; pollen 3-colporate; pistil 1, usually heterostyled, the carpels 3, the styles 3, free, elongate, stigmas terminal, fringed; ovary superior, unilocular, the ovules numerous to 3, parietal, bitegmic, crassinucellar, anatropous; fruit a loculicidal 3-valved capsule; seeds pitted, arillate; embryo straight, 0.9 to as long as the endosperm; cotyledons thin, 2.5 times wider than the radicle, 0.6 the length of the embryo; endosperm moderate, fleshy.

Composition: 7 genera, ~120 species.

Distribution: Tropical and subtropical America; southern $\frac{2}{3}$ of Africa, Madagascar.

ACHARIACEAE (Figure 63*c*).—Herbs and shrublets, sometimes scandent; xylem vessel perforation plates mostly simple, but also scalariform with few bars; leaves alternate, sometimes radical, simple, often palmately lobed, crenate or

serrate, exstipulate; inflorescences axillary racemes, fascicles, or the flowers solitary; plants monoecious; sepals 3–5, free or adnate to the corolla; petals 3–5, connate into a campanulate corolla; stamens 3–5, inserted on the corolla; staminodes 3–5, short, fleshy; anthers about as long as wide, the sacs separated by connective; pollen 3 (2)-colporate; pistil 1, the carpels 3–5, the styles 3–5, shortly connate, sometimes bifid apically, the stigmas apical; ovary superior, subsessile or stipitate, unilocular, the ovules 2–many per placenta, parietal; fruit a 3–5-valved capsule, the seeds pitted, arillate; embryo small, straight, 0.3 the length of the endosperm; cotyledons not broadened, 0.3 the length of the embryo; endosperm copious.

Composition: 3 genera, 3 species.

Distribution: South Africa.

CARICACEAE (Figure 63*d,e*).—Small trees and shrubs, rarely herbs, the sap milky; xylem vessel perforation plates simple; leaves alternate, simple, toothed, palmately lobed, or sometimes compound and 5–12-foliolate, exstipulate; inflorescences axillary racemes, panicles, cymes, fascicles, or the flowers solitary; plants mostly dioecious or monoecious, sometimes the flowers bisexual; sepals 5, connate; petals 5, connate, rarely free; stamens 10, in 2 series, rarely 5, inserted on the corolla, the filaments free or basally connate; anthers longer than wide, adnate, the connective often produced apically; pollen 3-colporate; pistil 1, the carpels 5, the styles 5, free or shortly connate, the stigmas apical, often fringed; ovary superior, 1- or 5-locular, the ovules numerous or few, parietal, bitegmic, crassinucellar, anatropous; fruit a berry, the seeds pitted or smooth, arillate; embryo straight, as long as the endosperm; cotyledons thin, 4.5 times wider than the radicle, 0.6–0.7 the length of the embryo; endosperm moderate or copious, fleshy.

Composition: 4 genera, ~50 species.

Distribution: Tropical America and west Africa; centered in South America.

VIOLACEAE (Figure 64*a,b*).—Shrubs and herbs, sometimes small trees or scandent; xylem vessel perforation plates simple, or scalariform

FIGURE 62.—LACISTEMATACEAE: *a*, *Lacistema robustum* inflorescence (enlarged), part of twig with inflorescences; *b*, *L. polystachyum* flower, ♂ flower, perianth, views of stamen, pistil; *c*, *L. grandifolium* disk, *L. myricoides* l.s. of ovary, *L. intermedium* fruit, *L. grandifolium* dehiscent fruit, valve of fruit; *d*, *L. pubescens* aril, seed with aril removed, l.s. of seed, embryo (after Martius, 1840–1906). PASSIFLORACEAE: *e*, *Passiflora serrata* flower, *P. alata* c.s. of ovary, l.s. of flower, seed, l.s. of fruit (after Martius, 1840–1906). MALESHERBIACEAE: *f*, *Malesherbia rugosa* flowering twig, l.s. of flower, *M. taltalina* flower laid open, dehiscent fruit, *M. rugosa* seed, l.s. of same (after Baillon, 1866–1895; Ricardi, 1967).

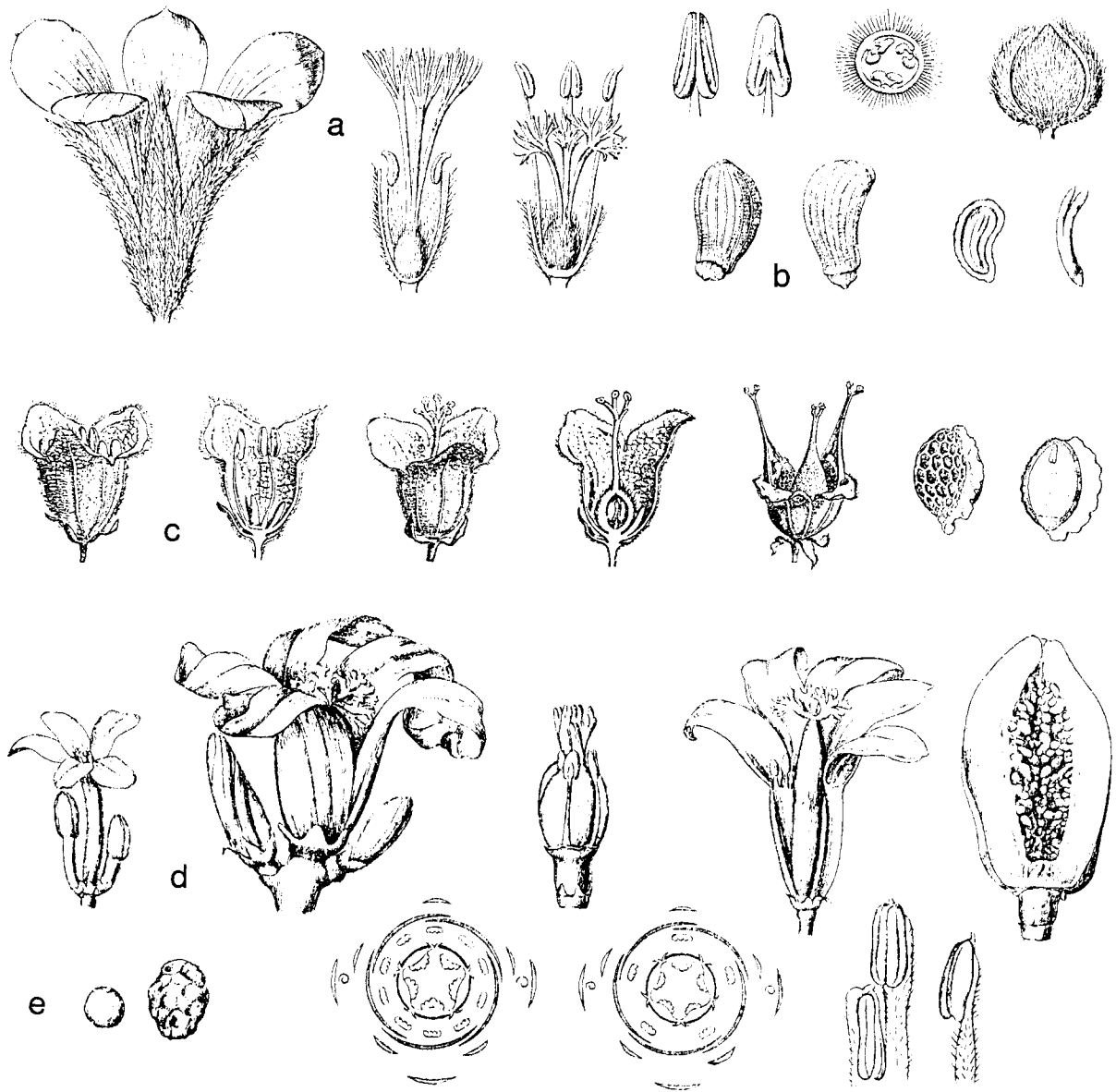


FIGURE 63.—TURNERACEAE: *a*, *Turnera lamiifolia* flower, l.s. of part of a longistylous flower, l.s. of part of a brevistylous flower, views of anther, c.s. of ovary, dehiscent fruit; *b*, views of seed, *T. diffusa* l.s. of seed, embryo (after Martius, 1840–1895). ACHARIACEAE: *c*, *Acharia tragioides* ♂ flower, l.s. of same, ♀ flower, l.s. of same, dehiscent fruit, seed, l.s. of same (after Baillon, 1866–1895). CARICACEAE: *d*, *Carica papaya* ♂ inflorescence, ♀ inflorescence, bisexual flower with corolla removed, opened flower, l.s. of young fruit; *e*, seed with succulent testa removed, seed, diagrams of 2 kinds of bisexual flowers, *Jacaratia dodecaphylla* views of stamen (after Martius, 1840–1906).

with few to numerous bars, or both; leaves alternate, rarely opposite, simple, entire or toothed, rarely lobed, stipulate; inflorescences axillary racemes, spikes, panicles, or the flowers solitary;

flowers actinomorphic or zygomorphic, bisexual, or the plants rarely polygamous or dioecious; sepals 5, free or rarely slightly connate; petals 5, free, rarely shortly connate, one often gibbous

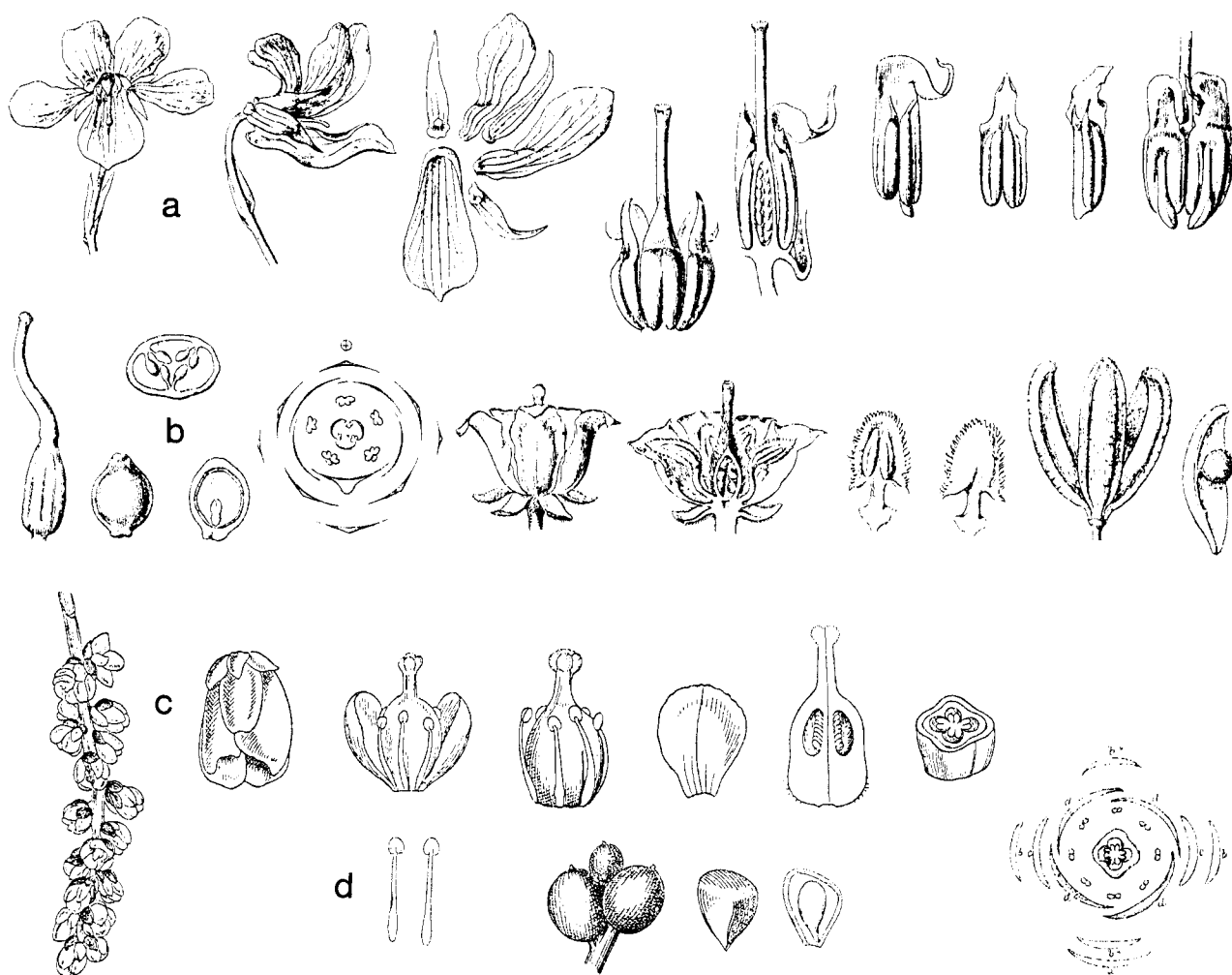


FIGURE 64.—VIOACEAE: *a*, *Viola subdimidiata* views of flower, 3 sepals and 3 petals, essential organs, l.s. of ovary and stamens, 3 views of stamen, 2 stamens with basal glands; *b*, pistil, c.s. of ovary, seed and l.s. of same showing the small embryo, floral diagram, *Alsodeia macrocarpa* flower, l.s. of same, views of stamen, *A. guianensis* dehiscent fruit, valve of fruit with a seed (after Martius, 1840–1906). STACHYURACEAE: *c*, *Stachyurus praecox* inflorescence, flower, same with part of perianth removed, essential organs, petal, l.s. of pistil, c.s. of ovary; *d*, views of stamen, fruits, seed, l.s. of same, floral diagram (after Hooker and Hooker, 1837–1982; Siebold and Zuccarini).

or spurred; stamens 5, mostly hypogynous, the filaments very short, free or connate; anthers basifixed or adnate, the connective produced apically, the 2 abaxial anthers sometimes spurred by a gland which secretes nectar into the petal spur; pollen 3 (–5)-colporate; pistil 1, the carpels 3 (2–5), the style 1, stigma(s) usually 1, apical, rarely 3–5-fid, rarely sessile; ovary superior,

sessile, unilocular, the ovules numerous to 1 per placenta, parietal, bitegmic, crassinucellar, anatropous; fruit a loculicidal capsule, rarely opening very early and exposing the unripe seeds, rarely densely echinate, rarely a berry or nutlet; seeds smooth or tomentose, often arillate, sometimes winged, rarely tomentose; embryo straight, 0.9 the length of the endosperm; cotyledons thin,

3.4–6.0 times wider than the radicle, 0.3–0.9 the length of the embryo; endosperm moderate or copious, rarely scanty, fleshy.

Composition: ~20 genera, ~900 species.

Distribution: Variety of habitats; cosmopolitan, but mainly north temperate, many Andine and some in the understory of rain forest in the tropics.

STACHYURACEAE (Figure 64*c,d*).—Shrubs or small trees, sometimes climbing; xylem vessel perforation plates scalariform, with few to many bars; leaves alternate, simple, serrate, stipulate; inflorescences axillary racemes or spikes; flowers bisexual or the plants polygamous, the parts hypogynous; sepals 4, free; petals 4, free; stamens 8, in 2 series, the filaments subulate, free; anthers small, about as long as wide, dorsifixed; pollen 3-colporate, occasionally 4-ruporate; pistil 1, the carpels 4, the style 1, stigma apical, very shortly 4-lobed; ovary superior, 4-locular, the ovules numerous, axile, or partly parietal, bitegmic, crassinucellar, anatropous; fruit a berry-like capsule; seeds numerous, small, arillate; embryo straight, as long as the endosperm; cotyledons elliptic, the radicle long or short; endosperm scanty or copious.

Composition: 1 genus, ~6 species.

Distribution: Himalayas to Japan, Taiwan.

SCYPHOSTEGIACEAE (Figure 65*a,b*).—Small trees with soft wood; xylem vessel perforation plates simple, few scalariform with few bars; leaves alternate, simple, pinnately veined, with numerous close transverse tertiary veins, distichous, serrate, stipulate; inflorescences terminal and axillary racemes or panicles; plants dioecious; perianth parts 6, similar, in 2 series, connate in the ♂, very shortly connate in the ♀; stamens 3, the filaments connate into a column, the anthers with common globose apical connective; pollen 3-colpate; 3 large glands at the base of the staminal column; pistil 1, the carpels 8–12 (–16), the stigmas sessile, forming a large fleshy disk with a small central ostiole; ovary superior, unilocular, the ovules numerous, basal, bitegmic, crassinucellar, anatropous; fruit fleshy, dehiscent apically by 8–12 (–16) valves; seeds numerous,

the embryo linear, straight; cotyledons as wide as the radicle, 0.5 the length of the embryo; endosperm scanty.

Composition: 1 genus, 1 species.

Distribution: Northwestern Borneo.

PERIDISCACEAE (Figure 65*c,d*).—Tree; xylem vessel perforation plates all or predominantly scalariform; leaves alternate, simple, distichous, entire, with 2 large pits at the base of the blade on the dorsal surface, stipulate; inflorescences clusters of short racemes, axillary, or at nodes of fallen leaves; flowers bisexual; sepals 4–5 (–7), free; petals 0; stamens ~16–20, the filaments elongated, basally connate; anthers small, about as long as wide, monotheous; pollen 3-colporoidate; disk large, cupular, lobed, surrounding the base of the ovary; pistil 1, the carpels 3–4, styles 3–4, filiform, short, free; ovary superior, unilocular, the ovules 6–8, apical; fruit a drupe, the seed 1, large; embryo straight, 0.3 the length of the endosperm; cotyledons thin, 1.2 times wider than the radicle, 0.5 the length of the embryo; endosperm copious, corneous.

Composition: 2 genera, 2 species.

Distribution: Amazon Brazil, Venezuela, Guayana.

HOPLESTIGMATACEAE (Figure 66*a,b*).—Trees; xylem vessel perforation plates simple; leaves alternate, simple, entire, exstipulate; inflorescences terminal subscorpioid cymes; flowers bisexual; sepals completely connate, the calyx splitting into 2–4 lobes at anthesis; petals 11–14, shortly connate, 3–4-seriate; stamens 20–35, 3-seriate, the filaments filiform, inserted on the base of the corolla; anthers elongated, oblong, dorsifixed; pollen 3-colpate; pistil 1, the carpels 2, styles 2, shortly connate, stigmas apical, reniform; ovary superior, unilocular, the ovules 2 per placenta, parietal; fruit a drupe, the seeds 4, oblong; embryo large, nearly straight, 0.9 the length of the endosperm; cotyledons broad, tapering gradually into the radicle; endosperm scanty.

Composition: 1 genus, 2 species.

Distribution: West tropical Africa.

LOASACEAE (Figure 66*c–h*).—Herbs, fre-

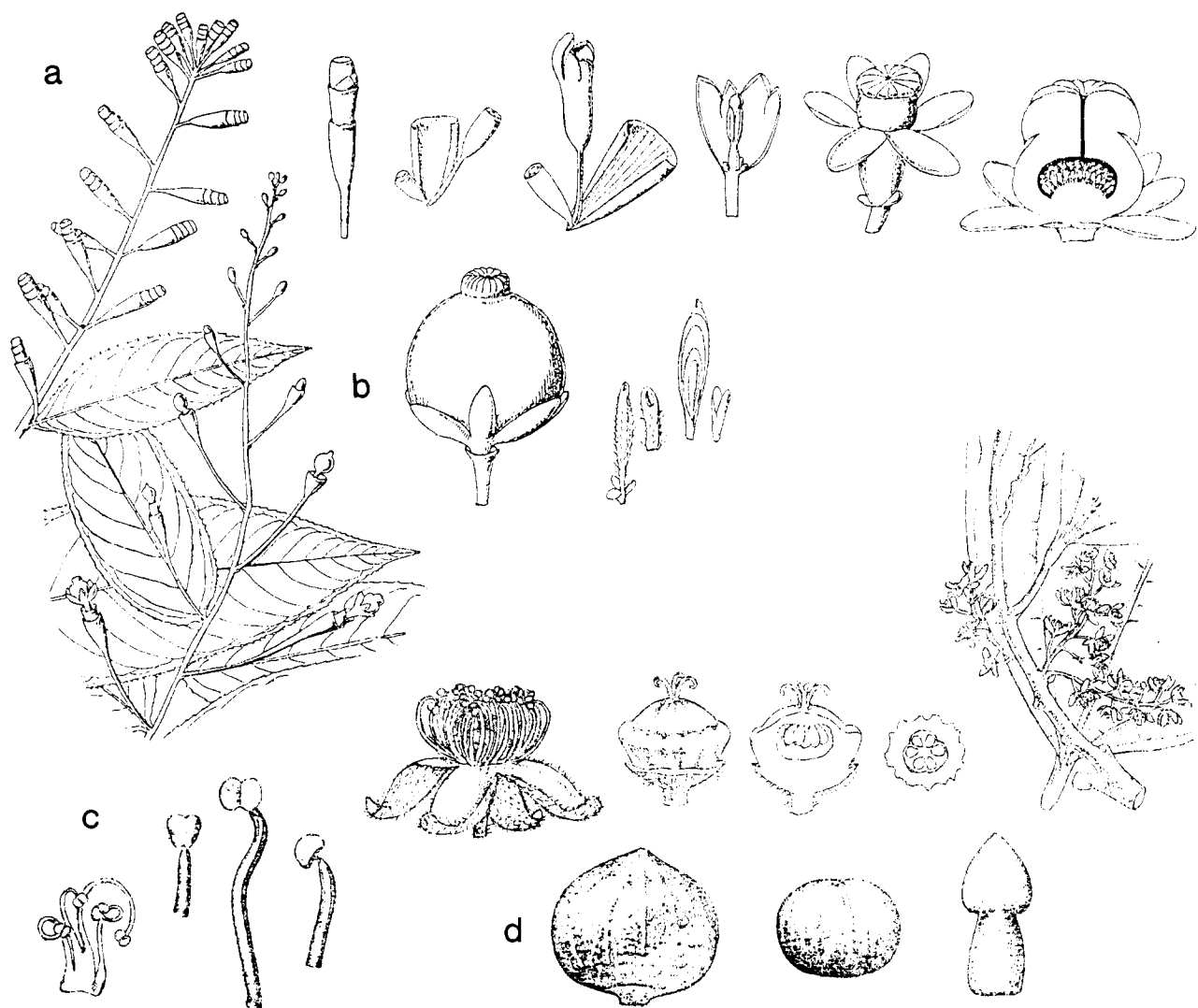
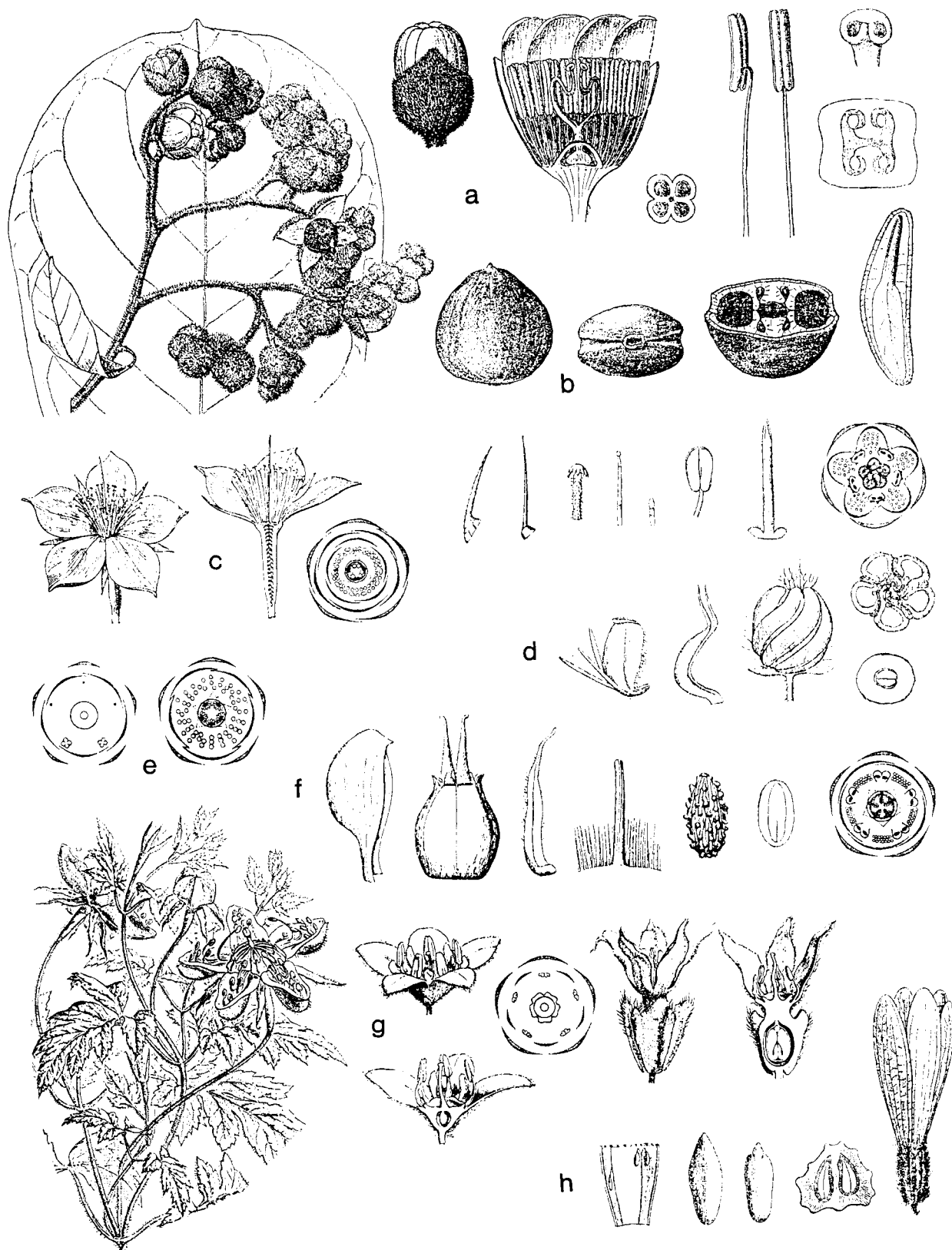


FIGURE 65.—SCYPHOSTEGIACEAE: *a*, *Scyphostegia borneensis* ♂ inflorescence, ♂ raceme, same with lower bract laid open, ♂ flower and bracts, l.s. of ♂ flower, ♀ flower, l.s. of same; *b*, ♀ flowering shoot, fruit, seed, apex of same, l.s. of same, embryo (after Hutchinson, 1973). PERIDISCACEAE: *c*, *Peridiscus lucidus* group of stamens, views of anther, flower, pistil with adnate fleshy disk, l.s. of pistil, c.s. of ovary, inflorescence; *d*, fruit, seed, embryo (enlarged) (after Kuhlmann, Oliver).

quently twining, or shrubs and low trees, mostly scabrid, the hairs often hooked, sometimes stinging; xylem vessel perforation plates simple; leaves alternate or opposite, simple, entire or divided and toothed, exstipulate or rarely stipulate; inflorescences axillary, terminal or oppositifolious cymes, often sympodial (monochasial), or heads, or the flower solitary; flowers bisexual, actino-

morphic; sepals 5 (4–7); petals 5 (4–7), sometimes 5 petaloid staminodes present, free or connate, inserted on the calyx; stamens numerous (to ~300) rarely 10 in 2 series, or 5 or only 2 fertile, in 1–5 series, the filaments long or short, mostly free, sometimes basally connate, often in bundles opposite the petals, sometimes adnate to the petals; anthers small, about as long as to 4 times



longer than wide, basifixed or dorsifixed, rarely 1-locellate, the connective sometimes produced apically; staminodes often present, petaloid or connate into nectar-collecting scales; pollen 3-colporate; sometimes disk around base of style or lining the calyx-tube; pistil 1, the carpels 3–5 (1–7), style 1, filiform, the stigma 1, punctiform, capitate or 3–7 and linear; ovary inferior, less frequently semi-inferior, 1–3-locular, the placentas 3–5 (–7), parietal, rarely apical or axile, the ovules numerous to 1 per placenta, unitegmic, tenuinucellar, anatropous or semi-anatropous; fruit a capsule, dehiscent apically, basally or laterally, loculicidal or septicidal or rarely indehiscent, woody and nut-like; seeds usually minute, rarely large, the testa smooth, reticulate, warty or punctate; embryo straight or bent, 0.3–1.4 times the length of the endosperm; cotyledons flat or plano-convex, 1–3 times as wide as the radicle, 0.3–0.8 the length of the embryo; endosperm copious, moderate or 0, fleshy or corneous.

Composition: 15 genera, 250 species.

Distribution: Centered in tropical and subtropical America, especially the Andes, extending slightly into temperate America; one genus in southern Arabia and southwestern Africa.

CUCURBITACEAE (Figure 67a–d).—Herbs, climbing or prostrate, usually with tendrils, rarely shrubs or small trees, often scabrid, the hairs rarely hooked; xylem vessel perforation

plates simple; sometimes the vascular bundles bicollateral, frequently arranged in 2 rings, and with some sieve tubes scattered in the cortex; leaves alternate, simple, entire or palmately lobed, divided or compound (*Zanonia*), often with extrafloral nectaries, exstipulate; inflorescences axillary cymes, racemes, thyrses, or the flowers solitary; plants monoecious or dioecious, or rarely the flowers bisexual (*Schizopepon*); sepals 5 (3–6), free or connate; petals 5 (4–6), connate or rarely free (*Fevillea*), rarely fringed or with ventral scales; stamens 3 (1–5), the filaments rarely free (*Fevillea*), usually inserted on the corolla-tube and united in pairs, the 5th free, sometimes all connate in a single central column; anthers free or connate, often unilocular, often sinuate, the connective often produced apically, staminodes rarely present in the ♂ (*Fevillea*); pollen 3-poly-colporate, 2-pantoporate, 7–9-colpate; sometimes a disk present at the base of the style; pistil 1, the carpels 3 (2–5), styles mostly 1, rarely 3 and free, the stigmas apical, or sometimes decurrent ventrally, thick, usually forked, rarely multifid (*Cucurbitella*); ovary inferior, unilocular or imperfectly 3-locular, the placentas 3 (2–5), parietal but often meeting in the axis, rarely subapical-axile, the ovules numerous to 1, bitegmic, crassinucellar, anatropous; fruit usually a berry, often with a firm wall, rarely a capsule (*Zanonia*), rarely circumscissile or a samara; seeds often flattened, sometimes winged; embryo straight, the cotyledons thin or moderately thick, 3–6 times wider than the radicle, 0.8–0.9 the length of the embryo, the radicle sometimes invested; endosperm 0.

Composition: ~100 genera, ~700 species.

Distribution: Pantropical and -subtropical, especially rain forest of South America and drier parts of Africa; few species in Australasia and temperate regions.

CISTALES

Shrubs, herbs, and small trees; xylem vessel perforation plates simple; leaves opposite or alternate, simple, entire, serrate, rarely lobed, stip-

FIGURE 66.—HOPISTIGMATACEAE: *a*, *Hoplostigma pierreanum* inflorescence, bud, l.s. of flower, c.s. of anther, views of stamen, stigma and c.s. of ovary; *b*, views of fruit, c.s. of fruit, l.s. of seed (after Engler). LOASACEAE: *c*, *Mentzelia aurea* flower, l.s. of same, *M. albescens* floral diagram, *Blumenbachia hieronymi* hairs, anther, style with disk, floral diagram; *d*, scale, staminode, fruit, c.s. of same and c.s. of endosperm and embryo; *e*, floral diagrams of *Petalonyx crenatus* and *Sympetaleia rupestris*; *f*, *Loasa parviflora* petal, scale and staminodes, staminode, style and disk, seed, l.s. of endosperm and embryo, *L. argemonoides* floral diagram; *g*, *Blumenbachia lateritia* flowering shoot, *Gronovia scandens* flower and l.s. of same, floral diagram, fruit, l.s. of same; *h*, *Kissenia spathulata* ovary laid open, seed, embryo, c.s. of fruit, fruit (after Martius, 1840–1906; Baillon, 1866–1895; Urban).

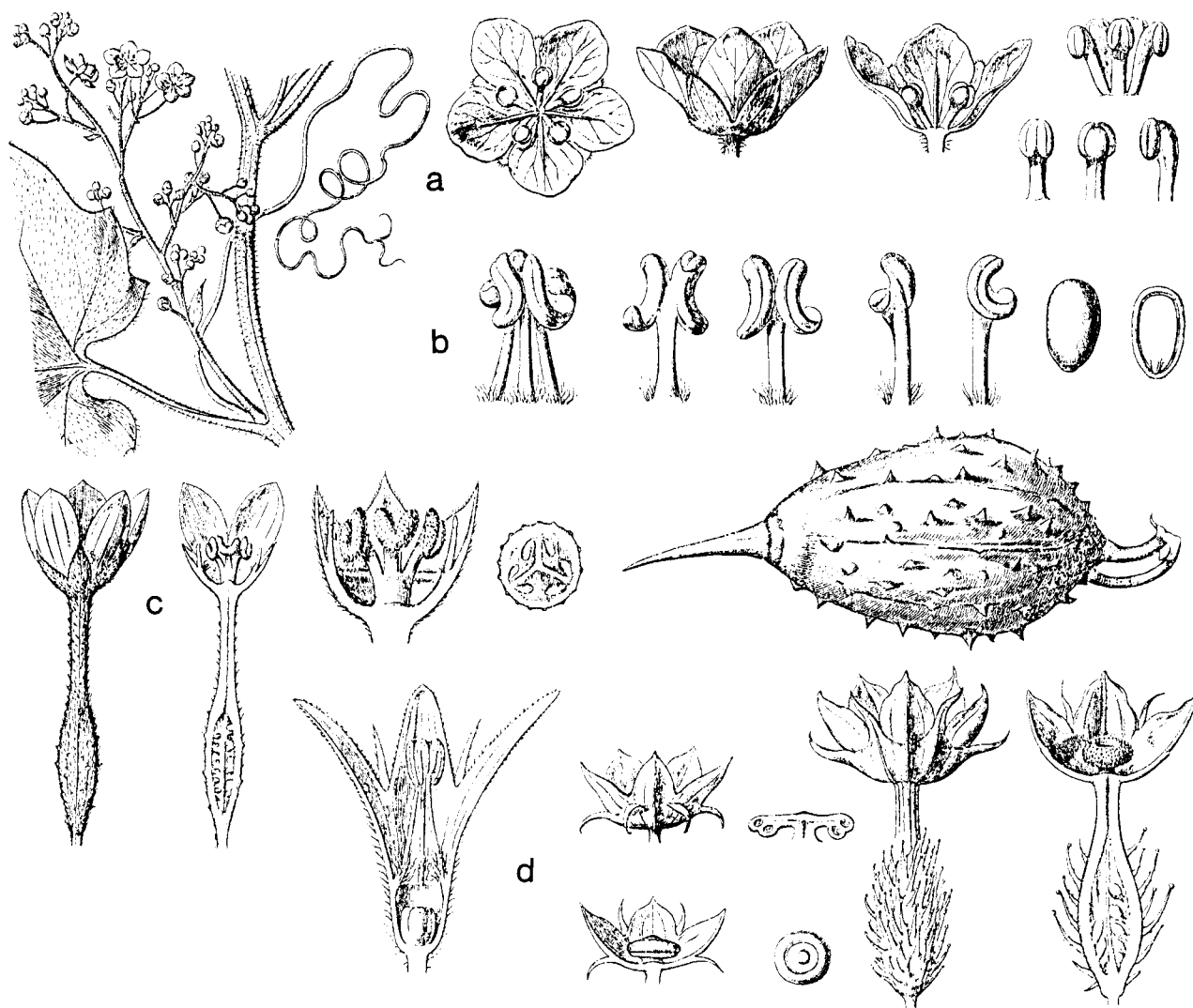


FIGURE 67.—CUCURBITACEAE: *a*, *Fevillea trilobata* ♂ inflorescence and tendril, ♂ flower (2 views), l.s. of same, androecium and views of stamen; *b*, *Luffa operculata* androecium, 2 views of bilocular stamen, 2 views of unilocular stamen, seed, l.s. of same; *c*, ♀ flower, l.s. of same, stigmas, style and staminodes, c.s. of ovary, fruit; *d*, *Cayaponia floribunda* l.s. of ♂ flower, *Cyclanthera elegans* ♂ flower and l.s. of same, l.s. of androecium and androecium from above, ♀ flower, l.s. of same (after Martius, 1840–1906).

ulate; flowers bisexual, often showy, the parts hypogynous; sepals 5, sometimes differing in width, free; petals 5 (3, 0), free; stamens usually numerous, ~25–200, rarely 3–6, the filaments free or rarely shortly connate, usually filiform, the anthers basifixed; pollen 3 (2–4)-colporate; glandular disk sometimes present; pistil 1, the carpels 2–5 (–10), style 1, the stigma(s) apical;

ovary 1 (3–5)-locular, the ovules numerous (–2), parietal, less commonly axile; fruit a loculicidal capsule; embryo arcuate or folded, rarely straight; endosperm usually copious.

Distribution: Temperate and tropical, most common in the Mediterranean region, in various habitats.

CISTACEAE (Figure 68*a,b*).—Glandular herbs

and shrubs; xylem vessel perforation plates simple; leaves opposite or rarely alternate, simple, entire, exstipulate or with stipules adnate to the petiole; inflorescence a cyme or the flower solitary, sometimes cleistogamous; flowers bisexual, actinomorphic, the parts hypogynous; sepals 5, free, the outer 2 usually smaller than the inner 3; petals 5 (3, 0), free, usually crumpled in bud, sometimes convolute, caducous; stamens numerous, ~25–100, or rarely 3–6, the filaments filiform, free, the anthers slightly longer than wide; pollen 3 (2–4)-colporate; disk present; pistil 1, the carpels 3 or 5 (–10), the style 1, long, short or absent, the stigma(s) apical; ovary unilocular or several locular due to placentas meeting in the center of the ovary, the ovules 2–numerous, parietal, bitegmic, crassinucellar, orthotropous or subanatropous; fruit a loculicidal capsule, dehiscent by 10–5 or 3 valves from the apex downward; embryo spatulate, bent, arcuate, coiled, folded or rarely straight, the cotyledons 2–6 times as wide as the radicle, 0.5–0.7 the length of the embryo; endosperm moderate, hard and transparent, starchy.

Composition: 8 genera, ~200 species.

Distribution: Dry sunny habitats, mostly north temperate zone, centered in the Mediterranean region; temperate and subtropical North America; temperate South America; Europe, western Asia.

COCHLOSPERMACEAE (Figure 68*c,d*).—Trees, shrubs, or subshrubs with yellow-red sap; xylem vessel perforation plates simple; leaves alternate, simple, palmately lobed, serrate, stipulate; inflorescence a raceme or panicle; flowers large, bisexual, the parts hypogynous; sepals 5, free; petals 5, free; stamens numerous (~80), free, the anthers linear, basifixed, dehiscent by apical pores or short slits; pollen 3-colporate; pistil 1, the carpels 3–5, the style 1, stigma(s) apical; ovary 1- or 3–5-locular, the ovules numerous, parietal or axile, bitegmic, crassinucellar, campylo-anatropous, the funicle rather long; fruit a 3–5-valved loculicidal capsule, the seeds often pilose, usually reniform; embryo large, arcuate, 0.8 the length of the endosperm, the cotyledons broad,

0.8 the length of the embryo; endosperm copious, oily.

Composition: 2 genera, ~25 species.

Distribution: Mostly dry habitats; tropical America from southwestern United States to northern half of South America, West Indies; tropical west Africa; India to Indochina, northern and northeastern Australia.

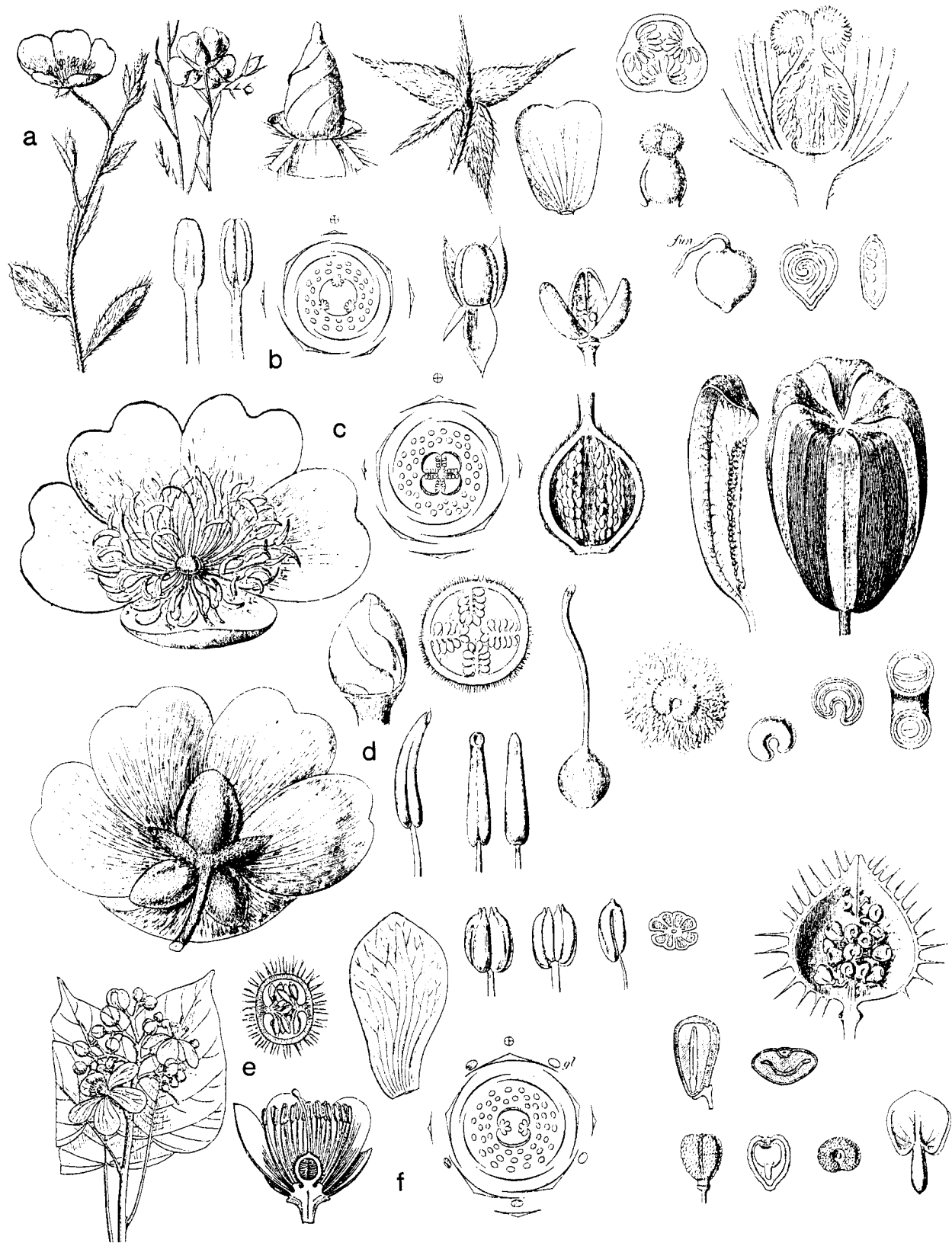
BIXACEAE (Figure 68*e,f*).—Shrubs or trees with mucous secretory canals; xylem vessel perforation plates simple; leaves alternate, simple, entire, basally palmatinerved, stipulate; inflorescence a terminal panicle, often thyrsoid; flowers bisexual, showy, the parts hypogynous; sepals 5, free, with 2 basal glands on the outside of each, 5 remaining after the fall of the sepals; petals 5, free; stamens numerous, ~200, free or shortly connate basally, inserted on an annular disk; anther sacs hippocrepiform, dehiscent apically by short slits; pollen 3-colporate; pistil 1, the carpels 2, the style elongated, filiform, stigma bilobed, apical; ovary unilocular, the ovules numerous, parietal, bitegmic, crassinucellar, anatropous, the funicle rather long; fruit a loculicidal capsule, the seeds covered by a red, fleshy testa; embryo arcuate, 0.9 the length of the endosperm, the cotyledons flat, thin, 2.8 times wider than the radicle, 0.7 the length of the embryo; endosperm copious, fleshy.

Composition: 1 genus, 1 or 4 species.

Distribution: Tropical America, West Indies, widely cultivated in the tropics.

ERICALES

Shrubs, small trees, and herbs, relatively rarely chlorophyllless; xylem vessel perforation plates scalariform with many or few bars, simple, or both; leaves mostly alternate, simple, entire or toothed, relatively rarely reduced to scales, rarely stipulate; flowers bisexual, more rarely unisexual, the parts hypogynous, rarely perigynous or epigynous; sepals 5 (2–10), free or connate, imbricate; petals 5 (2–8, 0), free or connate; stamens usually twice as many as the petals or corolla lobes, sometimes as many, hypogynous or rarely inserted on the corolla, the filaments usu-



ally free, rarely shortly connate; anthers basifixed or dorsifixed, sometimes with basal appendages, often dehiscent by apical pores; pollen 3 (2–5)-colporate or -colpate, sometimes in tetrads; glandular disk sometimes present; pistil 1, the carpels 5 (2–20), style 1, the stigma(s) apical; ovary locules 5 (2–20), very rarely 1, the ovules numerous to 1 per locule, axile, very rarely parietal, unitegmic, tenuinucellar; fruit usually a septicidal or loculicidal capsule, more rarely a berry or drupe, very rarely achene-like or a samaroid nutlet, the seeds often minute; embryo usually linear, sometimes minute; endosperm copious or moderate.

Distribution: Cosmopolitan, most common in temperate and arctic regions of the Northern Hemisphere, often in mountains in the tropics.

Chemistry: Chemistry favors separation of Diapensiaceae from Ericales. The chemistry of Cyrillaceae is little known, but in line with a position in Ericales.

ERICACEAE (Figure 69*a,b*).—Shrubs or subherbaceous, rarely trees or vines; xylem vessel perforation plates exclusively scalariform, with up to 20 or more bars, or simple, or both; leaves mostly alternate, rarely opposite or whorled, simple, entire, more rarely crenate or serrate, exstipulate; inflorescences terminal or axillary racemes or panicles or the flowers solitary; flowers usually bisexual, rarely the plants dioecious, the parts hypogynous, rarely perigynous or epigynous; sepals 5 (3–8), free or connate; petals 5

(3–8), mostly connate, sometimes free, rarely zygomorphic, usually imbricate, more rarely valvate; stamens usually twice as many as the corolla lobes, sometimes as many, obdiplostemonous, inserted on a nectariferous disk or rarely adnate to the corolla, the filaments free or rarely connate; anthers sometimes with basal tails and produced as tubes apically, often adnate, dehiscing by apical pores, very rarely by longitudinal slits; pollen usually in tetrads, 3 (2–4)-colporate; pistil 1, the carpels 5 (2–20), the ovary with as many locules (rarely 1-locular); placentas axile, rarely subbasal, often protruding into the locule, the ovules numerous to 1 per locule, unitegmic, tenuinucellar, anatropous, semi-anatropous or almost campylotropous, the style 1, the stigma apical, entire or lobed; fruit a septicidal or loculicidal capsule, berry or drupe; seeds small, often minute, the embryo usually straight, rarely curved, 0.5 to as long as the endosperm; cotyledons 1–2.5 times as wide as the radicle, 0.1–0.5 the length of the embryo; endosperm copious or moderate, fleshy.

Composition: ~60 genera, ~1500 species.

Distribution: Cosmopolitan; cool to subtropical regions and mountains of the tropics.

CLETHRACEAE (Figure 69*c,d*).—Shrubs and trees, the indument often stellate; xylem vessel perforation plates exclusively scalariform with 20–50 bars; leaves alternate, simple, serrate, exstipulate; inflorescences terminal racemes or panicles; flowers bisexual, the parts hypogynous; calyx deeply 5-lobed, the lobes imbricate, persistent; petals 5, free, imbricate; stamens 10 (12), obdiplostemonous, free; anthers not appendaged, the thecas separate half way, dehiscing by apical pores; pollen grains single or rarely in tetrads, 3-colporate; disk 0; pistil 1, the carpels 3, the style 1, 3-fid near the apex, the stigmas terminal; ovary 3-locular, the ovules numerous, axile, unitegmic, tenuinucellar, anatropous; fruit a loculicidal capsule; seeds minute, the embryo linear, straight, terete, 0.9 the length of the endosperm; cotyledons not broadened, 0.25 the length of the embryo; endosperm moderate, fleshy.

Composition: 1 genus, ~40 species.

FIGURE 68.—CISTACEAE: *a*, *Helianthemum brasiliense* flowering shoot, flower from below, corolla in bud, calyx laid open, petal, pistil and c.s. of ovary, l.s. of flower with apices of all parts except pistil cut off; *b*, views of anther, floral diagram, fruit and calyx, dehiscent fruit, seed showing long funicle, l.s. of seed in 2 planes (after Martius, 1840–1906). COCHLOSPERMACEAE: *c*, *Cochlospermum insignis* flower, floral diagram, l.s. of ovary, *C. codinae* valve of fruit, fruit; *d*, flower from below, corolla in bud, c.s. of ovary, views of anther, pistil, seed, seed with hair removed, l.s. and c.s. of seed (after Martius, 1840–1906). BIXACEAE: *e*, *Bixa orellana* flowering twig, c.s. of ovary, petal, views of anther, c.s. of same, valve of fruit with seeds; *f*, l.s. of flower, floral diagram, l.s. and c.s. of seed, views of seed and l.s. of same, embryo (after Martius, 1804–1906; Le Maout and Decaisne, 1873).

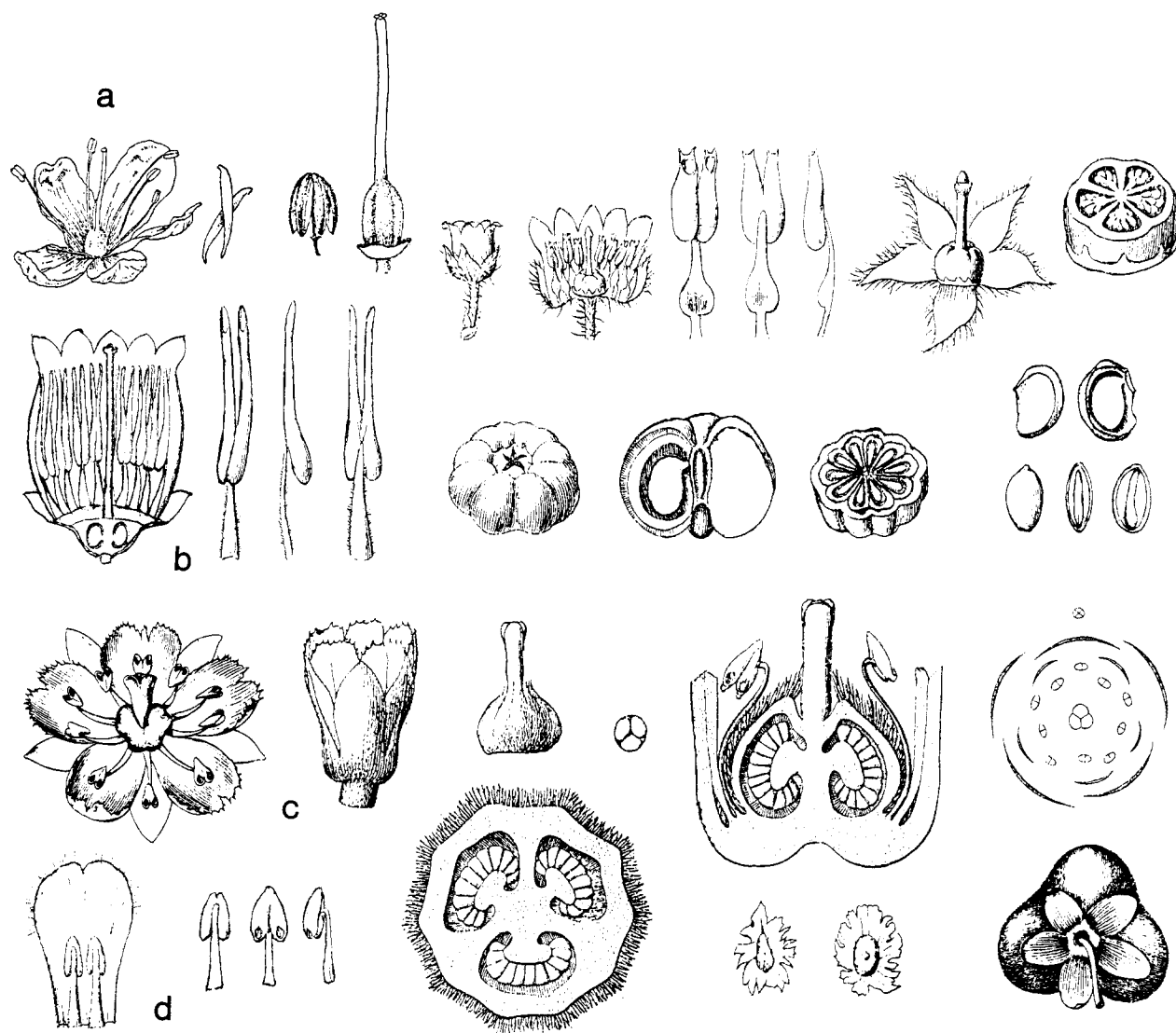


FIGURE 69.—ERICACEAE: *a*, *Ledum groenlandicum* flower, seeds, dehiscent fruit, pistil, *Pernettya myrtilloides* flower, same laid open, views of stamen, pistil and calyx, c.s. of ovary; *b*, *Gaylussacia rhododendron* l.s. of flower, views of stamen, fruit, l.s. and c.s. of same, pyrene and l.s. of same (above), seed, two l.s. of same (after Johnson; Martius, 1840–1906). CLETHRACEAE: *c*, *Clethra laevigata* flower, *C. spicigera* flower, pistil, stigma, l.s. of base of flower, floral diagram; *d*, petal and 2 stamens, views of stamen, c.s. of fruit, *C. laevigata* views of seed, fruit from below (after Le Maout and Decaisne, 1873).

Distribution: Eastern United States to north-western quarter of South America; Japan, China to the East Indies; Madeira.

PYROLACEAE (Figure 70*a*).—Herbs or slightly woody; xylem vessel perforation plates scalariform with numerous bars; leaves coriaceous, rad-

ical or on a short stem and alternate or subverticillate, rarely reduced, toothed or entire, exstipulate; inflorescence a terminal raceme, corymb or umbel or the flowers solitary and scapose, bisexual, the parts hypogynous; calyx 5 (4)-partite, persistent; petals 5 (4), free or rarely very

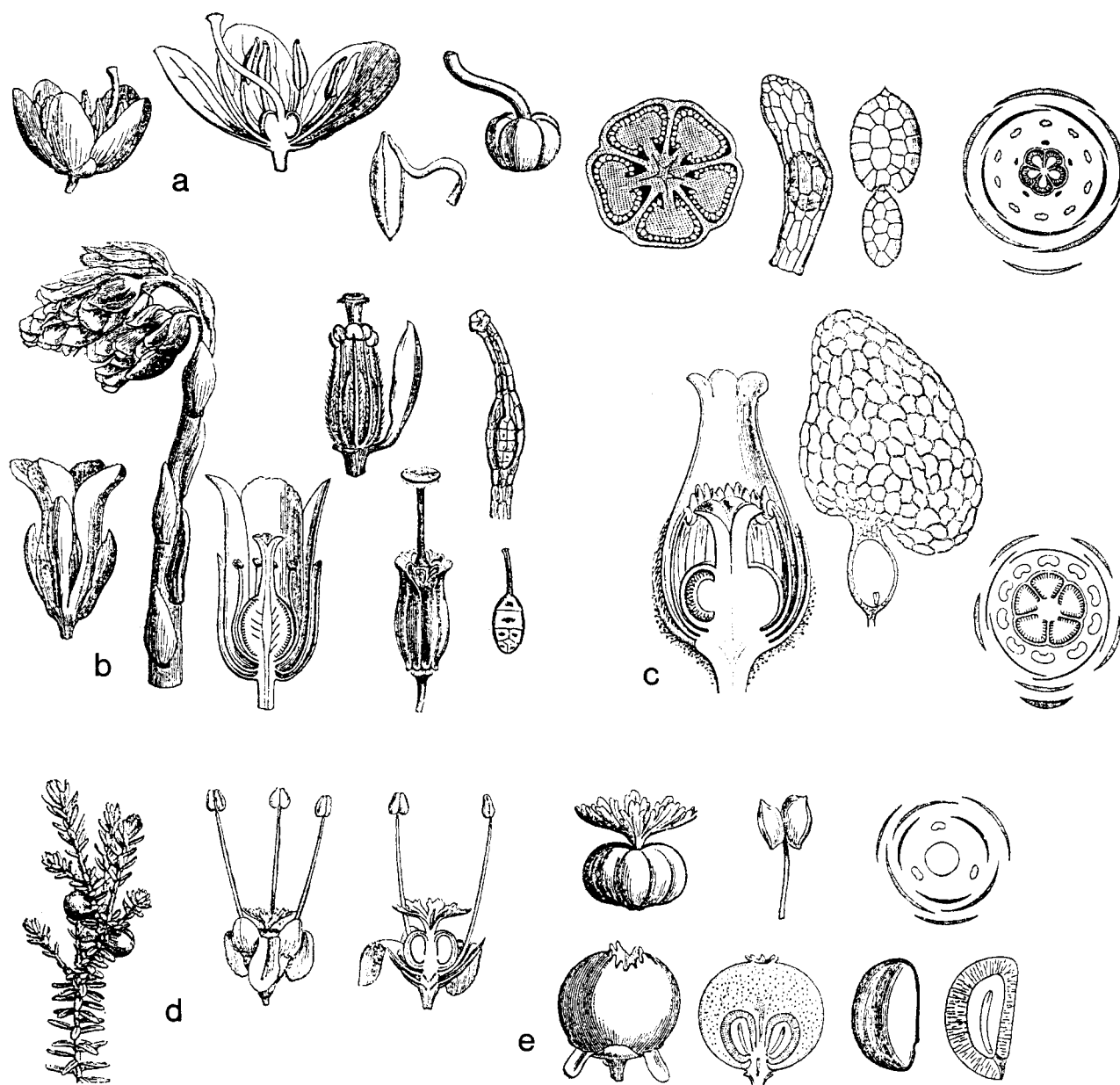


FIGURE 70.—PYROLACEAE: *a*, *Pyrola minor* flower, l.s. of same, stamen, pistil, c.s. of ovary, ovule, embryo taken out of the testa, floral diagram (after Le Maout and Decaisne, 1873). MONOTROPACEAE: *b*, *Monotropa hypopitys* flower, flowering plant, l.s. of flower, essential organs and perianth segment, dehiscent fruit, seed, undivided embryo; *c*, *Pterospora andromeda* l.s. of flower, l.s. of seed, *Monotropa hypopitys* floral diagram (after Le Maout and Decaisne, 1873; Baillon, 1866–1895). EMPETRACEAE: *d*, *Empetrum nigrum* fruiting twig, flower, l.s. of same, pistil, stamen, floral diagram; *e*, fruit, l.s. of same, pyrene, l.s. of same (after Le Maout and Decaisne, 1873).

shortly connate, imbricate, rarely with nectaries; stamens 10 (8), obdiplostemonous, free; anthers dorsifixed, dehiscent by 2 terminal pores; pollen single or in tetrads, 3-colporate; disk present or absent; pistil 1, the carpels 5 (4), the style 1, not divided apically, the 5 (4) stigmas apical; ovary imperfectly 5 (4)-locular (unilocular in upper part), the placentas axile, or parietal in the upper unilocular part of the ovary, fleshy, the ovules very numerous, unitegmic, tenuinucellar, anatropous; fruit a capsule, basally or apically loculicidally dehiscent; seeds minute, the embryo minute, undifferentiated, 0.7 the length of the endosperm; endosperm moderate or copious.

Composition: 4 genera, ~30 species.

Distribution: Temperate and arctic regions of the Northern Hemisphere.

MONOTROPACEAE (Figure 70*b,c*).—Chlorophyllless herbs, with hardly any vessels; leaves alternate, reduced to scales; inflorescence a terminal raceme or head, or the flower solitary; flowers bisexual, the parts hypogynous; sepals 2–6, free, imbricate; petals 3–6 (0), free or connate, imbricate; stamens 6–12, the filaments free or connate basally; anthers rarely spurred (*Pterospora*), dehiscent by chinks or slits; pollen grains single, 3–4 (2, 5)-colporate or colpate; disk present or absent; pistil 1, the carpels 4–6, the style 1, sometimes slightly lobed apically, the stigmas apical; ovary 1–6-locular, placentation parietal in the unilocular ovary, axile in those with more than 1 locule, the ovules very numerous, unitegmic, tenuinucellar, anatropous; fruit a loculicidal capsule; seeds minute, the embryo minute, 0.2–0.3 the length of the endosperm, the cotyledons 0.2 the length of the embryo; endosperm copious or moderate.

Composition: 12 genera, 20 species.

Distribution: Cool to warm temperate regions of the Northern Hemisphere, extending south to Colombia in mountains, and to Malaya.

EMPETRACEAE (Figure 70*d,e*).—Small ericoid shrubs; xylem vessel perforation plates scalariform with up to 10 bars, sometimes also simple; leaves crowded, coriaceous, alternate, entire, exstipulate; inflorescences axillary or terminal

heads or racemes; flowers bisexual or the plants dioecious, monoecious or polygamous, the parts hypogynous; sepals 3 (2), sometimes subtended by 2 pairs of bracts, imbricate, free, somewhat petaloid; petals 3 (2) or 0, free; stamens 2–4, the filaments filiform, free, long-exserted; anthers dorsifixed, dehiscent longitudinally; pollen usually in tetrads, 3-colporate; disk 0; pistil 1, the carpels 2–9, the style short, divided apically into 2–9 segments; ovary 2–9-locular, the ovules 1 per locule, axile, unitegmic, tenuinucellar, anatropous; fruit a drupe with 2–9 pyrenes; embryo linear, straight or slightly curved, terete, 0.7 to as long as the endosperm; cotyledons not broadened, 0.1–0.2 the length of the embryo; endosperm copious, fleshy.

Composition: 3 genera, 10 species.

Distribution: Heathlands of cool temperate regions; disjunct between northern North America and southern South America, and between eastern North America and southwestern Europe; southeastern United States; Azores and Canary Islands.

EPACRIDACEAE (Figure 71*a,b*).—Shrubs and small trees; xylem vessel perforation plates exclusively scalariform, sometimes with more than 20 bars, or simple or both; leaves alternate or rarely opposite, simple, coriaceous, entire or rarely crenate (*Wittsteinia*), exstipulate; inflorescences mostly racemes; flowers usually bisexual, sometimes the plants monoecious; sepals 5 (4), free, persistent; petals 5 (4), connate, rarely free (*Lysinema*) or calyptrate, imbricate or valvate; stamens 5 (4), rarely only 2 fertile, hypogynous or epipetalous, alternate with the corolla lobes; anthers rarely connate, dorsifixed, dehiscent longitudinally by 1 (2) slits; pollen in tetrads or single, 3-colporate; disk usually present, surrounding the base of the ovary; pistil 1, the carpels 5 (2–10), the style 1, elongate, the stigma capitate, apical; ovary superior, rarely inferior (*Wittsteinia*), 1–10-locular, the ovules 1–several per locule, axile, unitegmic, tenuinucellar, anatropous; fruit a loculicidal capsule or drupe with 10–1 pyrenes; embryo linear, terete, straight, 0.9 the length of the endosperm; cotyledons not

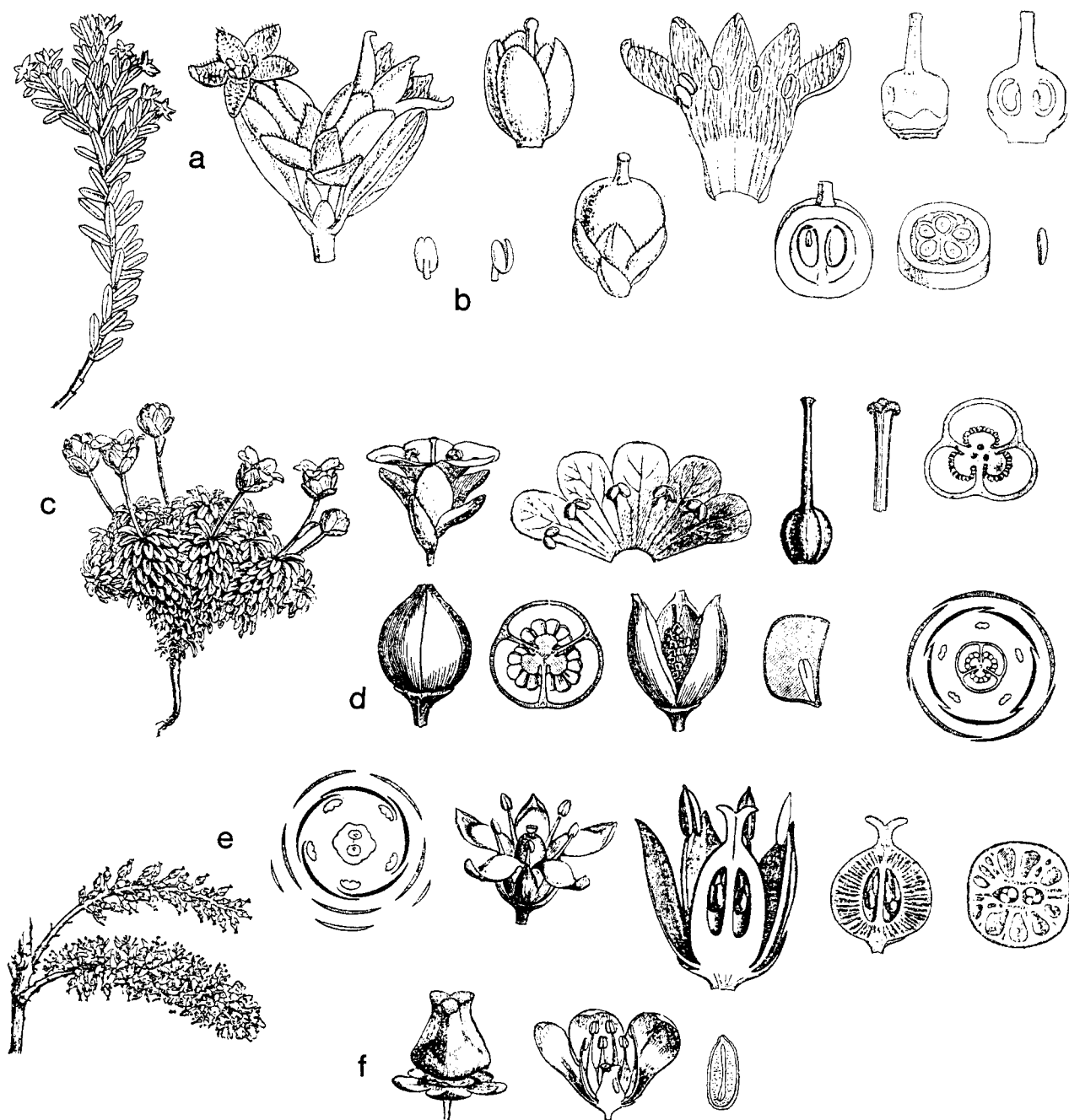


FIGURE 71.—EPACRIDACEAE: *a*, *Cyathodes colensoi* flowering twig, 2 flowers, flower with corolla removed, corolla laid open, pistil, l.s. of same; *b*, views of anther, fruit, l.s. and c.s. of same, embryo (after Cheeseman). DIAPENSIACEAE: *c*, *Diapensia lapponica* flowering plant, flower, corolla laid open, pistil, part of style and stigma, c.s. of ovary; *d*, fruit, c.s. of same, dehiscent fruit, l.s. of seed, floral diagram (after Le Maout and Decaisne, 1873). CYRILLACEAE: *e*, *Cyrilla racemiflora* part of twig with infructescence and inflorescence, floral diagram, flower, l.s. of same, l.s. and c.s. of fruit (enlarged); *f*, *Cliftonia monophylla* pistil and calyx, l.s. of flower, l.s. of seed (after Baillon, 1866–1895; Le Maout and Decaisne, 1873; Lindley, 1853).

broadened, 0.6 the length of the embryo; endosperm copious.

Composition: 30 genera, ~400 species.

Distribution: Centered in Australia; few species in New Zealand, Indochina and the East Indies, one in southern South America; Hawaii.

DIAPENSIACEAE (Figure 71*c,d*).—Small shrubs or subherbaceous; xylem vessel perforation plates simple, rarely also scalariform; leaves coriaceous, simple, entire or toothed, alternate or opposite, often basal, exstipulate; inflorescence a terminal raceme or subcapitate, or the flowers solitary; flowers bisexual; sepals 5, free or connate, the lobes imbricate, persistent; petals 5, connate, sometimes almost free, the lobes imbricate, sometimes fringed; stamens 5, epipetalous or hypogynous, alternate with the lobes, free or connate, the filaments short; 5 staminodes sometimes present; anthers basifixed, 2(1)-locular, dehiscing longitudinally or transversely by slits; pollen simple, usually 3-colporate; disk 0; pistil 1, the carpels 3, the style 1, elongate or short, the stigma apical, 3-lobed; ovary superior, 3-locular, the ovules few to many per locule, axile, unitegmic or also bitegmic(?), tenuinucellar, semi-anatropous or campylotropous; fruit a loculicidal capsule; seeds minute, the embryo linear, terete, straight or slightly curved, 0.5 the length of the endosperm; cotyledons not broadened, 0.3–0.4 the length of the embryo; endosperm copious, fleshy.

Composition: 6 genera, 20 species.

Distribution: Arctic and temperate Northern Hemisphere.

CYRILLACEAE (Figure 71*e,f*).—Shrubs and small trees, buds perulate; xylem vessel perforation plates exclusively scalariform with 20–50 (–70) bars; leaves alternate, simple, entire, exstipulate or stipules small and scarious; inflorescences racemes, terminal or at the apex of the previous year's wood; flowers bisexual, actinomorphic, the parts hypogynous; sepals 5 (6), free or rarely very shortly connate, quincuncial, imbricate, sometimes unequal; petals 5 (6), free or shortly connate, imbricate; stamens 5, or 10 in 2

whorls, the filaments elongate, sometimes broadened, free or adnate to the corolla at the very base (*Purdiaea*), the anthers small, dorsifixed, about as long as wide or oblong (*Purdiaea*), dehiscing longitudinally or by apical pores (*Purdiaea*); pollen 3 (4)-colporate, simple; disk weak, under the ovary; pistil 1, the carpels 2–4 (5), the style short, or elongated (*Purdiaea*), stigma(s) apical; ovary 2–4 (5)-locular, the ovules 1–2 (3) per locule, axile-subapical, unitegmic, tenuinucellar or weakly crassinucellar, anatropous, the funicle rather long; fruit small, indehiscent, the pericarp thin and dry, sometimes a samaroid nutlet, the mature seed devoid of a seed coat; embryo straight, usually cylindrical, 0.6–0.8 the length of the endosperm; cotyledons 0.25–0.3 (to 0.7 in *Purdiaea*) the length of the embryo, twice as wide as the radicle; endosperm copious, fleshy-hard.

Composition: 3 genera, 13 species.

Distribution: Marshy habitat; southeastern United States to the northern half of South America and the West Indies.

LENNOACEAE (Figure 72*a,b*).—Chlorophyllless, colored, parasitic, fleshy herbs; xylem vessel perforation plates simple, or xylem with only tracheids; leaves reduced to scales; inflorescence a terminal thyse or head; flowers bisexual; sepals 5–10, free and linear or connate nearly to the apex, persistent; petals 5–8, connate, the lobes short, imbricate; stamens epipetalous, 5–10, in 1 or 2 whorls, sometimes 2 staminodial, the filaments short or absent; anthers dehisce longitudinally; pollen simple, 3-colporate; disk 0; pistil 1, the carpels 6–15, the style 1, stigmas apical, 6–15; ovary 6–15-locular, superior, the ovules 2 per locule, axile, unitegmic, tenuinucellar, anatropous; fruit a capsular-drupe, the dehiscence circumscissile; seeds small; embryo globose, undifferentiated; endosperm copious.

Composition: 3 genera, 4 species.

Distribution: Deserts and coastal sand dunes; southwestern United States and northwestern Mexico; northern coast of Colombia and Venezuela; Revilla Gigedo Islands.

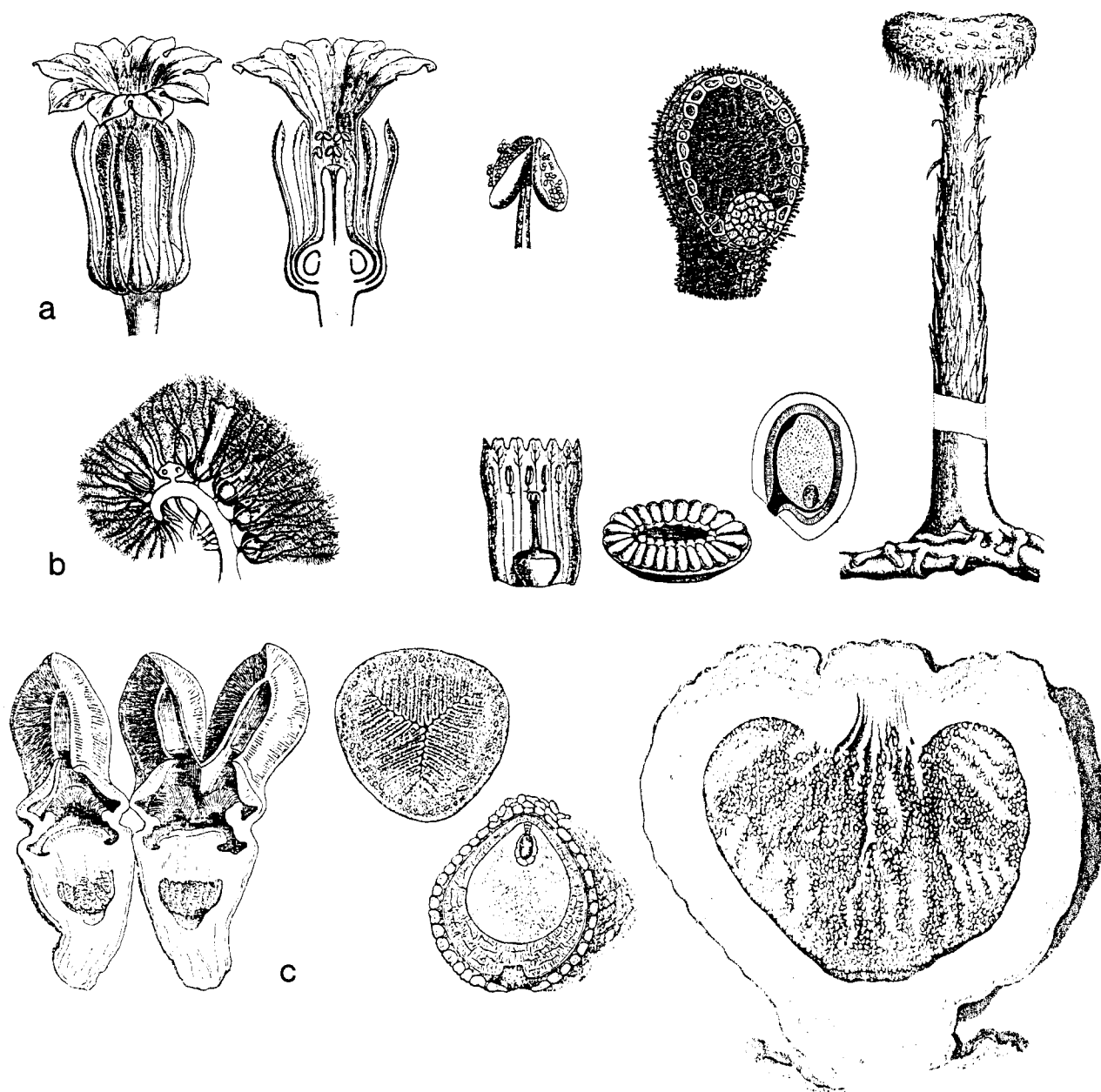


FIGURE 72.—LENNOACEAE: *a*, *Lennoa madreporoides* flower, l.s. of same, *L. coerulea* stamen, l.s. of seed showing embryo; *b*, *Ammobroma sonorae* part of inflorescence with buds, flower and young fruit, flower laid open, fruit showing the numerous pyrenes, l.s. of pyrene, plant (after Baillon, 1866–1895; Solms-Laubach; Torrey). HYDNORACEAE: *c*, *Hydnora africana* flower laid open, *Prosopanche burmeisteri* c.s. of ovary with 3 groups of placental lamellae, l.s. of seed, *Hydnora* sp. l.s. of fruit, (after Le Maout and Decaisne, 1873; R. Brown).

RAFFLESIALES

Chlorophyllless usually colored parasitic herbs; xylem vessel perforation plates simple, sometimes the vascular system reduced to tracheids; scale leaves present or absent, usually alternate; flowers usually unisexual; perianth segments 3–10, in 1–2 whorls, usually connate; stamens ~50–3, in 1–3 series, adnate to the perianth or connate in a column, the anthers connate; pollen 2 (3)-sulculate, 2–3-pored, 3 (4)-colpate or nonaperturate; pistil 1, the carpels 3–20, style 1, short, or the stigma(s) sessile; ovary inferior or semi-inferior, rarely superior, rarely partly several locular, ovules numerous, the placentas lamellate and parietal, or apical, or the ovules covering the wall of the ovary; fruit a berry, the seeds numerous, minute, the testa hard; embryo minute, undifferentiated; endosperm copious or scanty; perisperm copious or scanty.

Distribution: Mainly tropical and subtropical, western United States to southern South America; Asia, Africa, and western Australia, in wet and dry habitats.

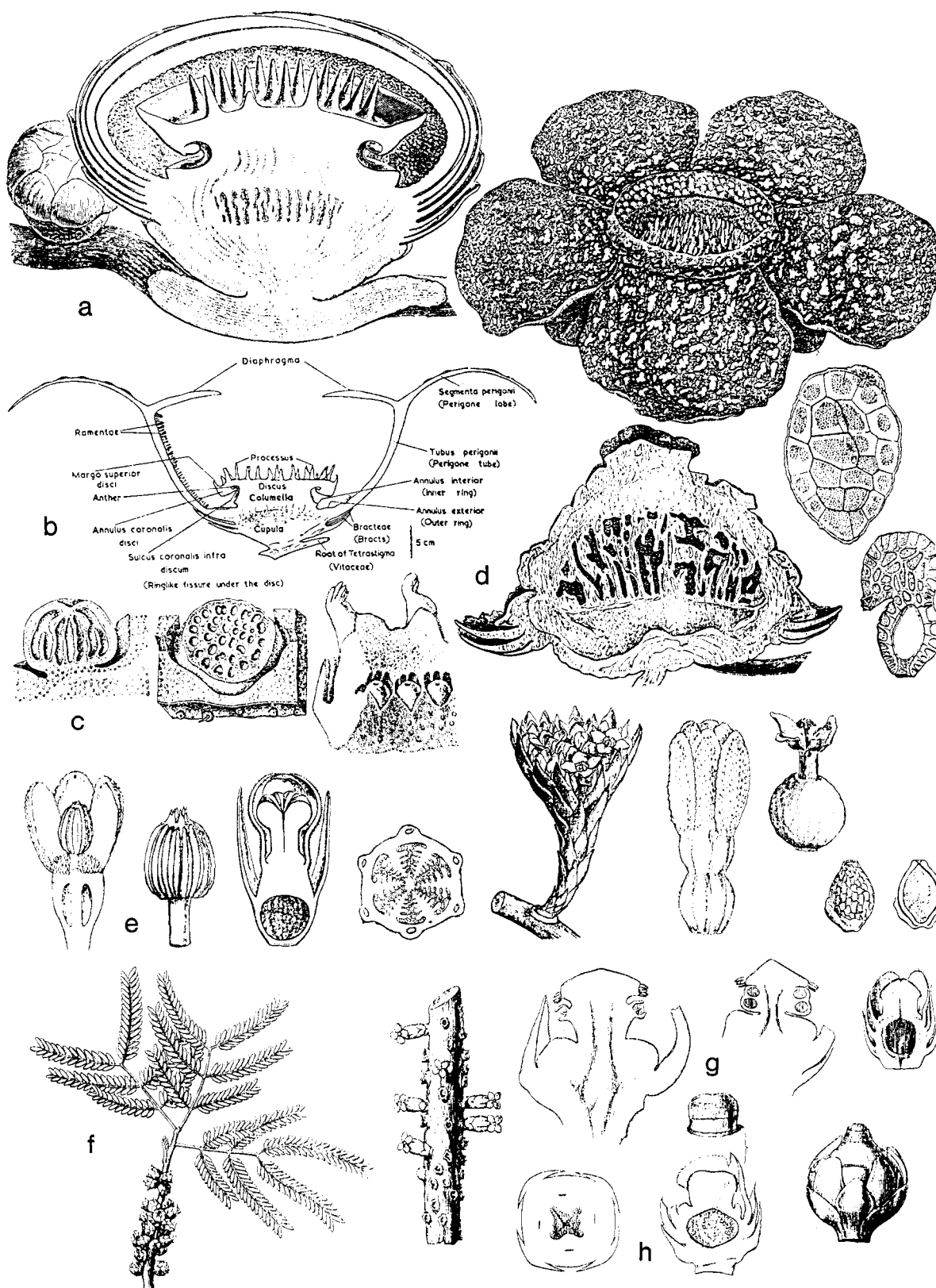
HYDNORACEAE (Figure 72*c*).—Chlorophyllless, colored, parasitic, fleshy herbs; vascular bundles of the rhizome-like structures may be in 1 or more irregular rings, the vessel perforation plates simple; sieve tubes definitely seen only in *Prosopanche*; scale leaves 0; flowers solitary, bisexual, very rarely unisexual, arising from a rhizome-like structure, actinomorphic, fairly large; perianth parts 3–4 (5) in one series, connate, thick, valvate; stamens 3–4 (5), the anthers large, sessile or subsessile, adnate to the perianth tube, connate and divided into numerous sinuous locelli, longitudinally dehiscent; pollen grains usually bilateral, 2 (3)-sulculate; pistil 1, the carpels 3–4 (5), the stigma subsessile, capitate, 3–4 (5)-sublobed; ovary inferior, unilocular, the ovules numerous, unitegmic, tenuinucellar, orthotropous, on numerous apical placentas or numerous lamellate, parietal placentas; fruit a berry, the seeds numerous, minute, the testa hard; embryo minute, undifferentiated, 0.3 the length of the endosperm; endosperm copious; perisperm copious or scanty.

Composition: 2 genera, 18 species.

Distribution: Dry habitats; tropical and southern Africa, Madagascar; warm temperate Paraguay and Argentina.

RAFFLESIACEAE (Figure 73*a–h*).—Herbs, often fleshy, chlorophyllless, colored or white (*Mitrastemon*) parasites of roots and stems of woody plants; vascular system very much reduced, merely tracheids, or vascular strands with simple perforation plates; leaves scales, spirally arranged or rarely opposite (*Mitrastemon*) or whorled; flowers usually solitary, terminal, sometimes smelling like carrion, the inflorescences rarely spikes, racemes or cymes (Cytineae), actinomorphic, minute to very large, rarely bisexual (*Mitrastemon*, *Rhizanthus*), usually the plants dioecious or monoecious, rarely polygamous; perianth parts 4–10, in 1 or 2 whorls, usually basally connate, rarely free, sometimes petaloid; anthers numerous (~50) to 8 in 1–3 series, round or elongate, sometimes the connective produced apically, bilocular or multilocellate, dehiscent longitudinally or by 1–2 apical pores, sessile and adnate to a central fleshy column, or the filaments connate in a column; pollen viscous, simple or in tetrads, 2–3-pored, 3 (4)-colpate or nonaperturate; nectary sometimes present (*Cytinus*), adnate to the base of the style and base of the staminal column; pistil 1, the carpels 4–20, style 1, short, or the stigma sessile, apical, simple, discoid and radially marked off (*Bdallophyton*) or lobate, or in a ring around the upper part of the

FIGURE 73.—RAFFLESIACEAE: *a*, *Rafflesia patma* l.s. of ♀ flower bud, *R. arnoldii* flower; *b*, l.s. of ♂ flower; *c*, l.s. and c.s. of anther, several anthers in position; *d*, *R. rochussenii* l.s. of fruit, *R. patma* seed testa with endosperm ejected (enlarged), endosperm and embryo (enlarged); *e*, *Cytinus dioicus* l.s. of ♂ flower, staminal column, *C. hypocistis* l.s. of ♀ flower, *C. dioicus* c.s. of ovary, *C. hypocistis* flowering plant, *C. dioicus* ♀ perianth, *C. hypocistis* fruit crowned by the perianth, seed, l.s. of same; *f*, *Pilostyles ingae* parasite on a legume, *Apodantes flacourtiæ* flowers; *g*, *Pilostyles caulotreti* l.s. of ♂ flower, l.s. of young ♂ flower, *P. blanchetii* l.s. of ♀ flower; *h*, *Apodanthes caseariae* c.s. of ovary, *Pilostyles caulotreti* l.s. of ♀ flower with annular stigma shown above, *P. ingae* fruit (after R. Brown; Baillon, 1866–1895; Meijer; Solms-Laubach; Harvey; Martius, 1840–1906; Karsten, 1958).



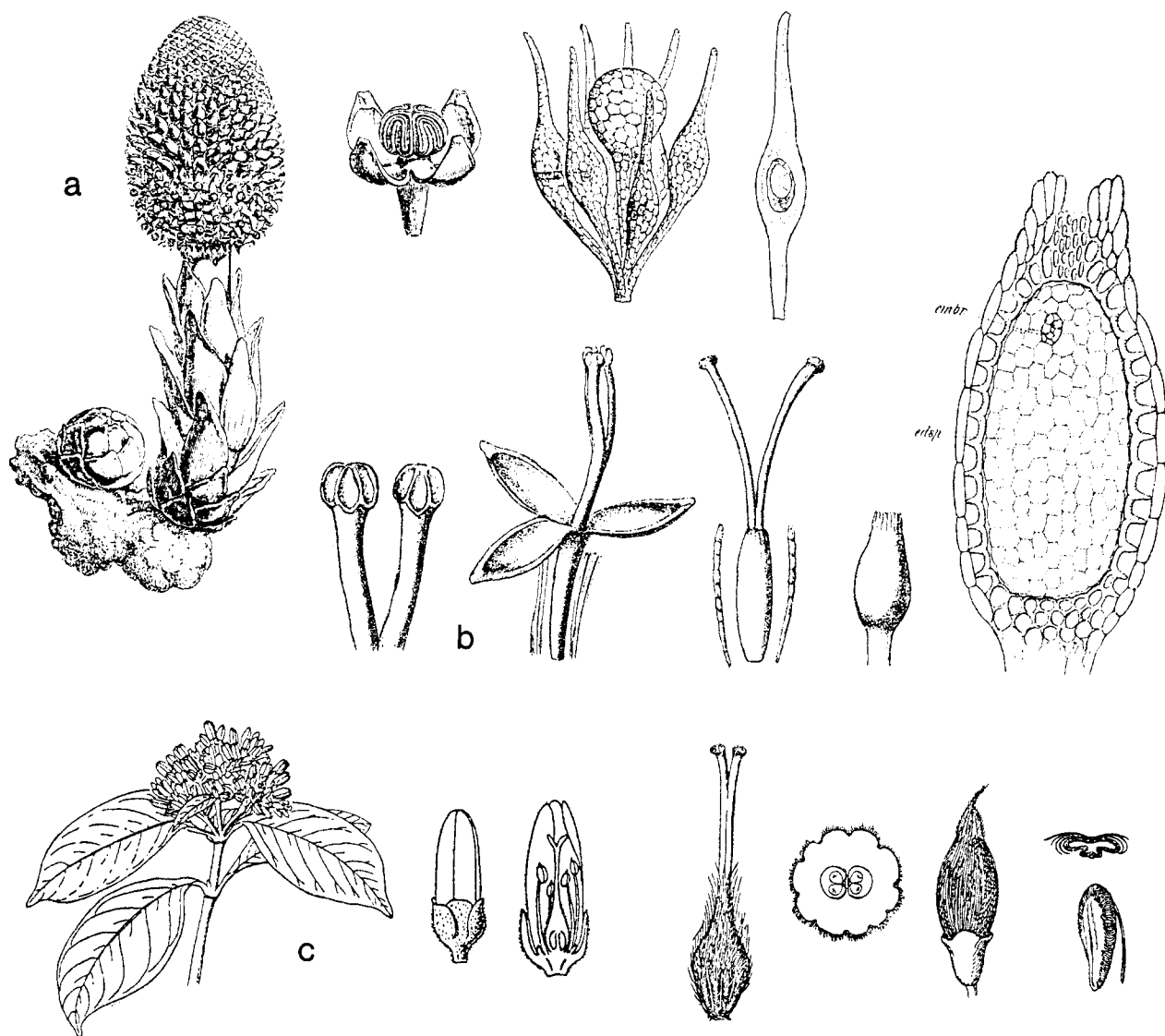


FIGURE 74.—BALANOPHORACEAE: *a*, *Balanophora dioica* ♂ plant and bud, ♂ flower, *B. fungosa* cluster of ♀ flowers surrounding a hair-like structure, l.s. of ♀ flower; *b*, *Helosis guyanensis* 2 stamens, ♂ flower, ♀ flower, fruit, l.s. of same (greatly enlarged) showing the minute embryo and copious endosperm (after Baillon, 1866–1895; Martius, 1840–1906). CTENOLOPHONACEAE: *c*, *Ctenolophon parvifolius* flowering twig, bud, l.s. of flower, *C. englerianus* pistil, c.s. of ovary, woody 1-seeded indehiscent fruit, seed with aril and c.s. of same (after Hutchinson, 1973; Winkler; Pierre).

column; ovary inferior or semi-inferior, rarely superior (*Mitrastemon*), unilocular, or several locular in the upper part (*Cytinus*), with many twisted locelli, the ovules numerous, on as many lamellate, parietal placentas as carpels or covering the wall of the ovary, 1–2-tegmic, tenuinu-

cellar, anatropous or orthotropous (*Cytinus*); fruit a berry, sometimes nearly dry, the seeds minute, very numerous, the testa hard; embryo minute, undifferentiated, surrounded by a unicellular layer of endosperm.

Composition: 8 genera, ~50 species.

Distribution: Mainly tropical and subtropical; western United States to southern tip of South America; central and southern Africa, Madagascar; Mediterranean region to Iran; Himalayas, Burma to Malaya, the East Indies; Japan; western Australia.

BALANOPHORALES

The order is monotypic.

BALANOPHORACEAE (Figure 74a,b).—Chlorophyllless rhizomatous fleshy herbs parasitic on tree roots, sometimes smelling like carrion; xylem vessel perforation plates simple, also scalariform(?); inflorescence a dense spike, head or panicle; flowers rarely bisexual, the plants usually monoecious or dioecious; ♂ flowers: perianth 3–4 (0, 2–8) parts, free or connate, valvate; stamens 1–2 in achlamydeous flowers, 3–10 in the others and opposite the perianth parts, the filaments free or basally connate; anthers 1-multilocellate, free or connate, dehiscing by pores or slits; pollen 3(–5)-colpate, 3–4(2–5)-por(or)ate, or 4-polyfor(amin)ate; ♀ flowers: perianth absent or 3-lobed; pistil 1, the carpels 1–3(–5), the styles 1–3 (–5), often filiform, free, the stigmas apical, capitate, or absent and the stigma sessile and discoid; ovary inferior or superior, 1–3(–5)-locular, the ovules 1 per locule, 0–1-tegmatic; fruit a nutlet or drupelet, the seed 1; embryo minute, undifferentiated, 0.3 the length of the endosperm; endosperm relatively copious.

Composition: 18 genera, ~100 species.

Distribution: Pantropical, usually in moist upland forest.

CELASTRALES

Trees and shrubs, sometimes climbers; xylem vessel perforation plates scalariform usually with fewer than 20 bars, simple, or both; leaves alternate or opposite, simple, entire or toothed, exstipulate; flowers bisexual, rarely unisexual, small; sepals 5 (3, 4), free or shortly connate; petals 5 (3, 4, 0), free, very rarely shortly connate; stamens 5 (2–20), hypogynous or perigynous, the filaments short or filiform, usually free,

sometimes shortly connate, the anthers dorsifixed or basifixed; pollen 3(2, 7–9)-colporate; glandular disk present, often conspicuous; pistil 1, the carpels 2–5, styles 1, 2 or 5, usually short, the stigmas apical or very rarely decurrent; ovary superior or semi-inferior, rarely inferior, 2–5(10)-locular, the ovules 1–2(to ~14) per locule, axile; fruit a drupe, nut, loculicidal or septicidal capsule, samara, schizocarp or berry; seeds often arillate, the embryo usually large, endosperm copious to absent.

Distribution: Nearly cosmopolitan, mainly tropical and subtropical, usually lacking in cool and cold regions.

CTENOLOPHONACEAE (Figure 74c).—Trees; xylem vessel perforation plates scalariform, usually with less than 25 bars, but more numerous in one species; leaves opposite, coriaceous, simple, entire, stipulate; inflorescences terminal and axillary cymes; flowers bisexual, the parts hypogynous; sepals 5, shortly connate, imbricate; petals 5, free, thick, linear-oblong, spoon-shaped basally; stamens 10, the filaments elongated; anthers about as long as wide, dorsifixed; pollen 7–9-colp(oroid?)ate; disk cupular, external to the stamens; pistil 1, the carpels 2, styles 2–1, elongated, stigmas apical, capitate; ovary 2-locular, the ovules 2 per locule, axile-subapical; fruit a nut, the seed arillate.

Composition: 1 genus, 3 species.

Distribution: Tropical western Africa, western Malaysia.

IXONANTHACEAE (Figure 75a).—Trees and shrubs; xylem vessel perforation plates simple; leaves alternate, simple, entire or serrate, stipulate; inflorescences lateral cymes, racemes, panicles or fascicles; flowers bisexual, the parts hypogynous; sepals 5, free or shortly connate; petals 5, free, sometimes persistent and becoming indurated; stamens 20, 15, 10, or 5, the filaments filiform, elongated, shortly connate; anthers small, about as long as wide, dehiscing longitudinally; pollen 3-colporate; disk conspicuous, annular or cupular, internal to the stamens; pistil 1, the carpels 5–2, style 1, elongated or 5 and free nearly to the base; ovary 5–2-locular, the

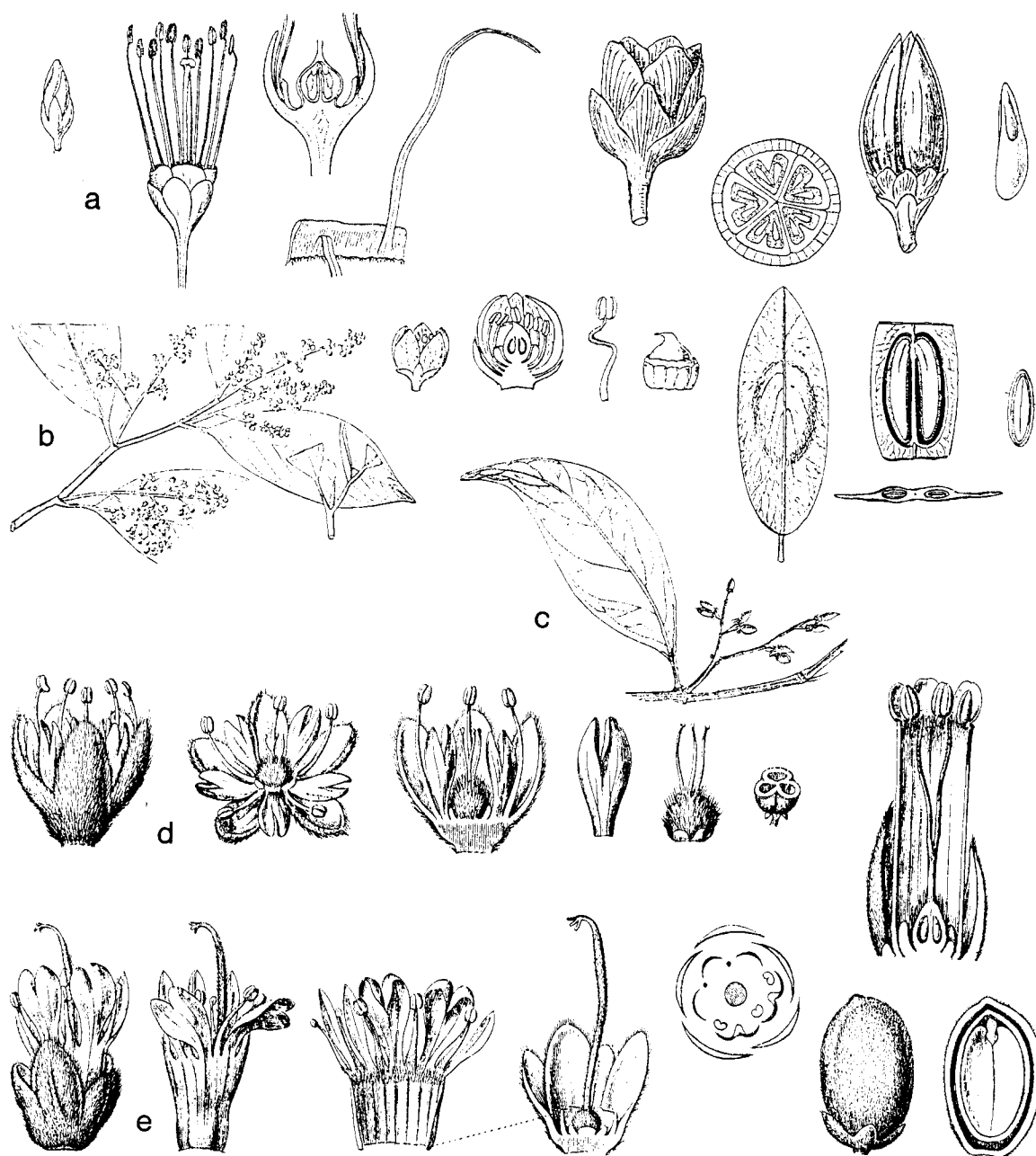


FIGURE 75.—IXONANTHACEAE: *a*, *Ixonanthes icosandra* bud, *I. papuana* flower, l.s. of base of flower, part of outer surface of disk with 2 adnate filaments, *I. cochinchinensis* flower, c.s. of fruit, dehiscent fruit, seed (after Lecomte; Ridley; Hutchinson, 1973; Oliver). IRVINGIACEAE: *b*, *Desbordesia glaucescens* flowering twig, apex of young twig (superimposed on leaf) showing large stipules, flower, l.s. of same, stamen, pistil and disk, fruit, l.s. and c.s. of same, c.s. of seed; *c*, *Irvingia barteri* part of twig with infructescence (after Hutchinson, 1973; Oliver). DICHAPETALACEAE: *d*, *Dichapetalum rugosum* flower from side and from above, l.s. of same, petal, pistil and disk, c.s. of fruit, *Stephanopodium engleri* l.s. of flower; *e*, *Tapura amazonica* flower, same with calyx removed, corolla laid open showing insertion of stamens, l.s. of flower (corolla cut off), floral diagram, fruit, l.s. of same (after Martius, 1840–1906).

ovules 2–1 per locule, axile-subapical, bitegmic, anatropous; fruit a septicidal capsule, the seeds sometimes arillate; embryo often oblique or lateral; endosperm fleshy.

Composition: 7 genera, ~40 species.

Distribution: Tropical Asia, America, and Africa.

IRVINGIACEAE (Figure 75*b,c*).—Trees; xylem vessel perforation plates simple; leaves alternate, simple, entire, coriaceous, the stipules large; inflorescences axillary and terminal panicles; flowers bisexual, small, the parts hypogynous; sepals 5, free or shortly connate; petals 5, free; stamens 10, the filaments free, elongated; anthers about as long as wide, sub-basifixed, dehiscing longitudinally; pollen 3-colporate; disk conspicuous, cupular, surrounding the base of the ovary; pistil 1, the carpels 5, 4, or 2, style 1, short, the stigma apical, punctiform; ovary 5, 4, or 2-locular, the ovules 1 per locule, axile-subapical, bitegmic, anatropous; fruit 1, 5 or 4 drupes or broadly winged samara; embryo straight, as long as the endosperm; cotyledons broad, flat, 0.3 the length of the embryo; endosperm scanty or 0.

Composition: 3 genera, 10 species.

Distribution: Tropical Africa, Indochina, Malaya, Borneo, Sumatra.

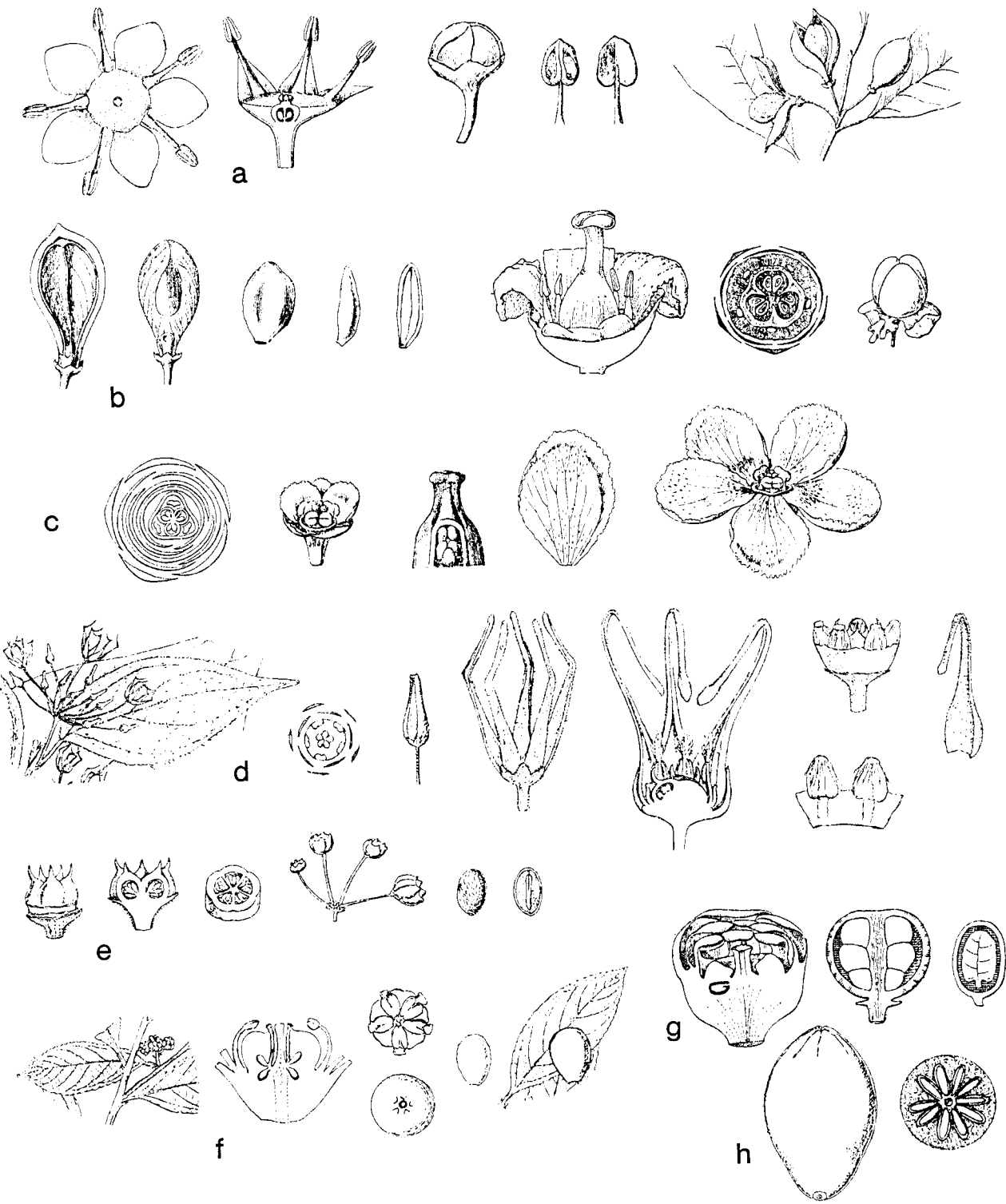
DICHAPETALACEAE (Figure 75*d,e*).—Small trees and shrubs, often lianas; xylem vessel perforation plates simple, sometimes also scalariform with up to 10 or more bars; leaves alternate, simple, entire, often with a few flat glands near the base below, distichous, stipulate; inflorescences axillary and terminal or adnate to the petiole; flowers bisexual or the plants polygamodioecious, small, actinomorphic or zygomorphic; sepals 5 (4), free or shortly connate; petals 5 (4), mostly bilobed, free or united with the stamens into a tube; stamens 5 (4), some of these sometimes staminodal, the filaments long or short; anthers about as long as wide, the connective often dorsally thickened, dehiscing longitudinally; pollen (2) 3-colporate; disk cupular or lobed, or of separate glands opposite the petals; pistil 1, the carpels 2–3 (4), style 1 or 2–3-fid and basally connate, the stigmas 2–3, apical; ovary

superior to inferior, 2–3-locular, the ovules 2 per locule, carunculate, axile-subapical; fruit a drupe, sometimes the epicarp splitting, mostly 1-seeded; embryo large, straight, the cotyledons thick, plano-convex, 12 times broader than the radicle, 0.97 the length of the embryo; endosperm 0.

Composition: 4 genera, ~200 species.

Distribution: Panropical, few subtropical; centered in Africa.

CELASTRACEAE (Figure 76*a–c*).—Trees, shrubs, and climbers, some genera with secretory sacs or laticiferous canals; xylem vessel perforation plates mostly simple, rarely exclusively scalariform with fewer than 10 bars except in *Perrottetia*, occasionally both simple and scalariform; leaves alternate or opposite, rarely 0, simple, entire or toothed, stipulate or exstipulate; inflorescences axillary, rarely epiphyllous(?), mostly cymose or fasciculate, rarely racemose or solitary; flowers small, often bisexual, rarely the plants polygamodioecious; sepals (3) 4–5, free or connate; petals 4–5 (3, 0), free, rarely basally connate (*Microtropis*), imbricate or rarely valvate; stamens 4–5 (2, 3), alternipetalous, the filaments often short, rarely shortly connate (*Hippocratea*), hypogynous or perigynous, sometimes inserted on the disk; anthers about as long as wide, longitudinally dehiscent, rarely transversely (*Hippocratea*); pollen usually 3-colporate; disk usually present, cupular or flat, surrounding, or beneath the ovary; pistil 1, the carpels 2–5, styles 1 or 5, short, the stigmas 2–5, apical; ovary superior, rarely semi-inferior (*Mortonia*), 1–5-locular, the ovules mostly 2 per locule, sometimes 1 to ~14 per locule, axile, rarely apical, bitegmic, crassinucellar or tenuinucellar, anatropous; fruit a loculicidal, rarely septicidal capsule, schizocarp, samara, drupe or berry; seeds often with a colored aril, the embryo rather large, rarely minute (*Perrottia*), straight, or the radicle very slightly curved, to 0.9 the length of the endosperm; cotyledons flat, thin or moderately thick, 1.7–4.0 times wider than the radicle, 0.6–0.9 the length of the embryo; endosperm moderate, copious or 0, fleshy.



Composition: ~55 genera, ~850 species.

Distribution: Cosmopolitan except arctic and cool temperate regions of the Northern Hemisphere; mainly tropical and subtropical.

GOUPIACEAE (Figure 76*d,e*).—Trees and shrubs; xylem vessel perforation plates scalariform with 3–10 bars, the vessel members very long; leaves alternate, simple, entire, (dentate in seedlings), stipulate; inflorescences axillary, pedunculate, subumbellate racemes; flowers bisexual; sepals 5, connate, the lobes imbricate; petals 5, free, valvate, with long, narrow apices; stamens 5, the filaments very short, inserted on the disk; anthers small, the connective produced apically, the locules separate; pollen 3-colp(oro)idate; disk cupular, partly enclosing the ovary; pistil 1, the carpels 5, styles 5, short, free, the stigmas apical; ovary superior or semi-inferior, 5-locular, the ovules several per locule, axile-basal; fruit a drupe, the seeds several; embryo straight, 0.8 the length of the endosperm; cotyledons oblong, not broadened?, 0.5 the length of the embryo; endosperm copious, fleshy.

Composition: 1 genus, species 3.

Distribution: Guayana, northern Brazil.

SIPHONODONTACEAE (Figure 76*f–h*).—Trees and lianas; xylem vessel perforation plates simple; leaves alternate, toothed or subentire, stipulate; inflorescences axillary, cymose-umbelliform, 1–4-flowered; flowers bisexual; sepals 5, free or basally connate, imbricate; petals 5, free, imbricate;

stamens 5, oppositisealous, the filaments short, inserted external to the disk, free or connate; sometimes also 5 staminodes present; anthers small, basifixed; pollen 3-porate; disk present; pistil 1, the carpels 5, styles 5, short, adnate to the ventral wall of the ovary, the stigmas apical and decurrent; ovary superior, 10-locular, 2–6 ovules per locule; fruit a drupe with 10 or 20 pyrenes; cotyledons large, flat, foliaceous, broadly ovate or orbicular, subcordate basally, the radicle short; endosperm copious or moderate, rather bony or horny.

Composition: 1 genus, 5 species.

Distribution: Southeastern Asia, Malaysia, northeastern Australia.

RHAMNALES

Trees and shrubs, often climbing, rarely herbs; xylem vessel perforation plates simple or scalariform with few or many bars, or both; leaves usually alternate, simple or compound, toothed or entire, rarely lobed, stipulate or exstipulate; flowers small, bisexual or unisexual, the parts hypogynous or perigynous; sepals 4–5 (–9), connate, small; petals 4–5 (–9, 0), free, more rarely connate; stamens 4–5 (–22), often opposite the petals; filaments free or rarely connate or inserted on the calyx-tube or petals, the anthers often dorsifixed; pollen 3(4–6)-colporate, -colpate, -porate or nonaperturate; glandular disk surrounding the base of the ovary or absent; pistil 1, the carpels 2–4 (–22), style 1, usually short, the stigmas apical or sometimes sessile; ovary superior to inferior, 1–4(–22)-locular, the ovules 1–2 (3) per locule, axile, subapical or subbasal; fruit a berry or drupe, rarely a schizocarp, nut, samara or septicidal capsule; embryo minute to large; endosperm copious to absent.

Distribution: Cosmopolitan, most common in tropical and subtropical regions, in various habitats.

Chemistry: Gibbs does not feel there is any strong argument from chemistry for close relation of Rhamnales and Celastrales. Rhamnaceae are noted for their quinones, which have not been reported elsewhere in the order.

FIGURE 76.—CELASTRACEAE: *a*, *Maytenus floribunda* flower, l.s. of same (petals removed), *M. communis* bud, views of stamen, fruiting twig; *b*, dehiscent fruit, seed enclosed in aril, views of seed, l.s. of same, *Celastrus scandens* l.s. of ♀ flower with staminodes and disk, floral diagram, fruit with calyx; *c*, *Cuervia kappleriana* floral diagram, bud, l.s. of pistil, petal, flower (after Martius, 1840–1906; Johnson). GOUPIACEAE: *d*, *Goupia glabra* axillary inflorescence, floral diagram, bud, flower, l.s. of same, cupular disk surrounding essential organs and 2 stamens inserted on inner face of disk, petal; *e*, pistil, l.s. and c.s. of ovary, fruits, seed, l.s. of same (after Baillon, 1866–1895; Oliver; Hutchinson, 1973). SIPHONODONTACEAE: *f*, *Siphonodon celastrineus* axillary inflorescence, l.s. of flower (sepals and petals cut off), view from above of anthers appressed to disk and view of disk from above showing the 5 stigmas and ostiole, sepal, petal on leaf; *g*, l.s. of bud, l.s. of fruit, l.s. of seed; *h*, fruit, c.s. of same (after Hutchinson, 1973; Lecomte).

VITACEAE (Figure 77a).—Mostly lianas, often with tendrils and swollen nodes; xylem vessel perforation plates simple; leaves alternate, rarely also opposite, simple or compound, toothed, very rarely entire, sometimes lobed, stipulate; inflorescences leaf-opposed, cymose in spikes, racemes, panicles; flowers minute, bisexual or the plants dioecious or polygamomonoecious, the parts hypogynous; sepals 4–5 connate nearly to the apex, small; petals 4–5, free or apically connate, valvate; stamens 4–5, opposite the petals, the filaments free, anthers free, dorsifixed; pollen as a rule 3-colporate, sometimes with 4 or 6 furrows; disk usually annular or cupular, surrounding the base of the ovary; pistil 1, the carpels 2, style 1, usually short, the stigmas apical; ovary 2-locular, the ovules 2 per locule, axile, bitegmic, crassinucellar, anatropous; fruit a berry, the seed(s) with hard testa; embryo minute, straight, 0.2–0.4 the length of the endosperm; cotyledons 1.5–2.0 times wider than the radicle, 0.4–0.5 the length of the embryo; endosperm copious, fleshy, sometimes ruminant.

Composition: 12 genera, ~700 species.

Distribution: Pantropical and -subtropical, much rarer in temperate zones.

LEEACEAE (Figure 77b).—Trees, shrubs, and herbs, without tendrils; xylem vessel perforation plates simple; leaves alternate, very rarely opposite, compound, rarely simple, usually toothed, exstipulate; inflorescences terminal, very rarely axillary, usually corymbose or cymose, the flowers bisexual; sepals 5–4, connate; petals 5–4, basally connate, valvate; stamens 5–4, opposite the petals, the filaments connate, inserted on the corolla, the anthers extrorse; pollen 3-colporate; pistil 1, the carpels 3–8, style 1, stigma apical; ovary 3–8-locular, the ovules 1 per locule, axile; fruit a berry; embryo small, thin, the cotyledons very small, radicle long, straight or slightly curved; endosperm fleshy, ruminant.

Composition: 1 genus, 70 species.

Distribution: Palaeotropics, mostly southern and eastern Asia, in moist forest.

RHAMNACEAE (Figure 77c,d).—Trees and shrubs, sometimes thorny, often climbing, very

rarely herbs, tendrils rarely present; xylem vessel perforation plates simple, also occasionally scalariform with few bars; leaves usually alternate, sometimes opposite, rarely absent, simple, toothed or entire, mostly stipulate; inflorescences axillary, cymose or racemose, usually corymbiform; flowers small, bisexual or the plants rarely polygamodioecious; sepals 5 (4), connate, valvate; petals 5 (4) or 0, small, free; stamens 5 (4), the filaments free or inserted on the calyx-tube, opposite the petals; anthers about twice as long as wide; pollen usually 3-colporate; disk mostly present, perigynous, sometimes lining the calyx-tube; pistil 1, the carpels 3 (2–5), style 1, sometimes shortly lobed, the stigmas apical; ovary superior to inferior 3(1–5)-locular, the ovules 1 (2) per locule, axile-subbasal, bitegmic, crassinucellar, anatropous; fruit a drupe, berry, schizocarp, nut or rarely samara or septicidal capsule; embryo large, straight, rarely bent, as long as the endosperm; cotyledons thin or moderately thick, 3–6 times wider than the radicle, 0.9 the length of the embryo; endosperm mostly moderate, sometimes scanty or 0, fleshy, sometimes ruminant.

Composition: 58 genera, ~900 species.

Distribution: Cosmopolitan except part of the arctic region; most common in tropical and subtropical regions.

ERYTHROPALACEAE (Figure 77e).—Scandent shrubs or lianas, sometimes with tendrils; xylem vessel perforation plates simple; leaves alternate, simple, entire, exstipulate; inflorescences axillary, cymose, lax; flowers bisexual, the parts usually perigynous; sepals 5, basally connate; petals 5, free, valvate; stamens 5, opposite the petals, the filaments short, inserted on the base of the petals; anthers small, about as long as wide; pollen 3-colpate; disk large, partly enclosing the ovary; pistil 1, the carpels 3, style 1, short, the stigmas 3, apical; ovary semi-inferior, initially 3-locular, becoming unilocular, the ovules 3–2, apical, unitegmic, tenuinucellar, anatropous; fruit a drupe, the seed 1; embryo minute, 0.2 the length of the endosperm; cotyledons not broadened, about 0.6 the length of the embryo; endosperm copious, fleshy.

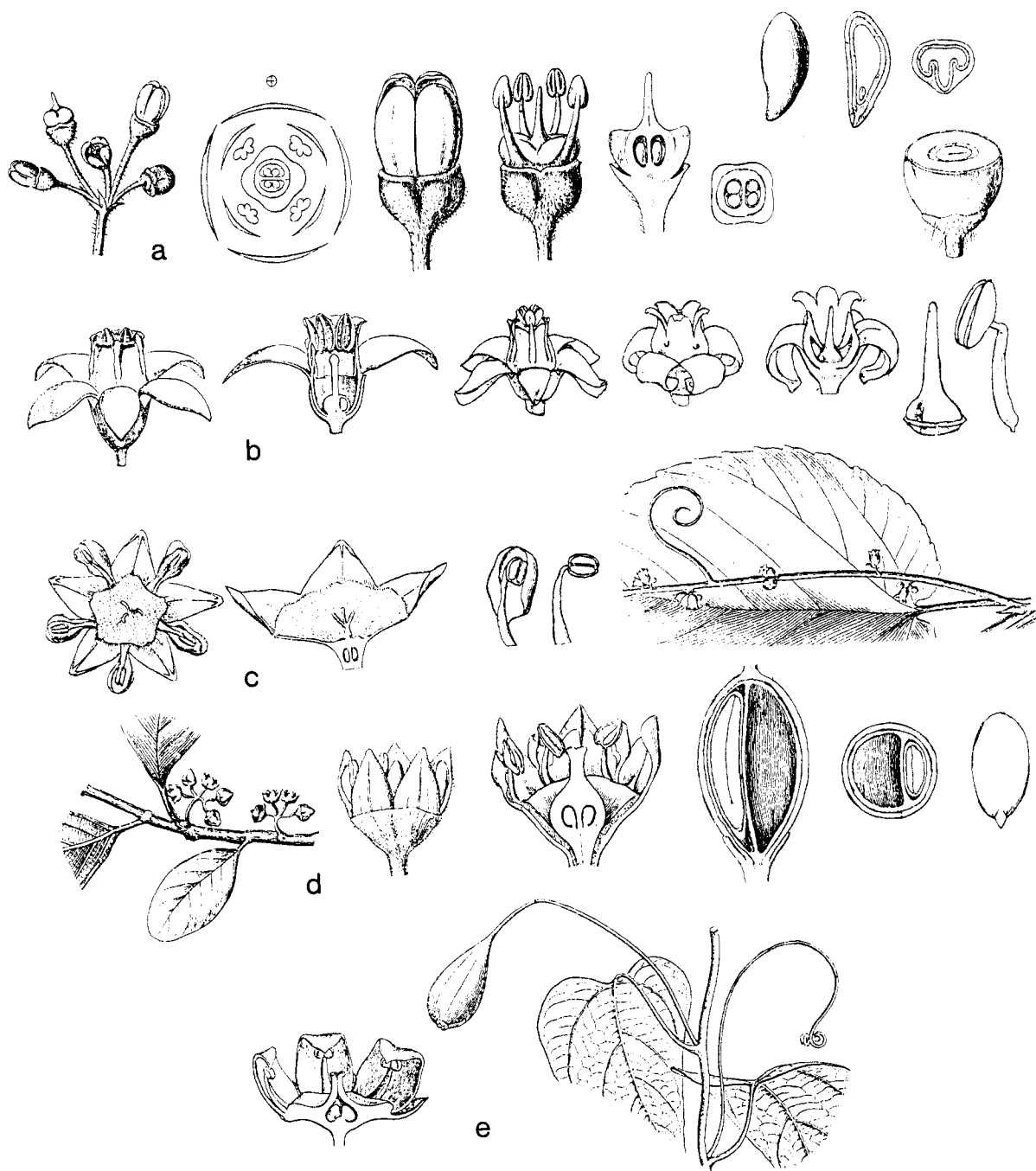


FIGURE 77.—VITACEAE: *a*, *Cissus scabra* part of inflorescence, floral diagram, flower, same with petals fallen, l.s. and c.s. of ovary, *Vitis vinifera* seed, l.s. of same showing the minute embryo and copious endosperm, c.s. of seed, *Cissus salutaris* c.s. of immature fruit (after Martius, 1840–1906). LEEACEAE: *b*, *Leea sambucina* flower, l.s. of same, *L. coccinea* flower, same with stamens removed from the urceolus, l.s. of flower, pistil and hypogynous disk, stamen (after Baillon, 1866–1895; Hooker and Hooker, 1837–1982). RHAMNACEAE: *c*, *Gouania latifolia* flower, l.s. of same, petal and stamen, stamen, part of inflorescence; *d*, *Rhamnidium elaeocarpum* inflorescences, flower, l.s. of same, l.s. and c.s. of fruit, l.s. of embryo (after Martius, 1840–1906). ERYTHROPALACEAE: *e*, *Erythropalum scandens* l.s. of flower, fruiting twig (after Baillon).

Composition: 1 genus, 2 species.

Distribution: Eastern Himalayas to the East Indies.

AQUIFOLIACEAE (Figure 78a,b).—Trees and shrubs; xylem vessel perforation plates exclusively scalariform, mostly with more than 20 bars; leaves alternate, very rarely opposite, simple, usually toothed, stipulate or exstipulate; inflorescences axillary cymes or fascicles, rarely racemes or the flowers solitary; plants mostly dioecious, sometimes polygamodioecious, some of the flowers bisexual, the parts hypogynous; sepals 4 (5–9), connate, imbricate, minute; petals 4 (5–9 or 0), free or shortly connate, imbricate or valvate (*Phelline*); stamens 4 (5–22), the filaments free or adnate to the base of the corolla; anthers about as long as wide; pollen 3-colporoidate; disk absent; pistil 1, the carpels 4 (3–22), stigma usually sessile, rarely a short style present; ovary 4(3–22)-locular, the ovules 1 (2) per locule, axile-apical, unitegmic, crassinucellar or tenuinucellar, anatropous; fruit a drupe with 4 (3–22) pyrenes; embryo minute, 0.1 the length of the endosperm, barely differentiated; endosperm copious, fleshy.

Composition: 3 genera, ~400 species.

Distribution: Nearly cosmopolitan; most numerous in Asia and South America.

ICACINACEAE (Figure 78c–f).—Trees, shrubs, and lianas, rarely herbs; xylem vessel perforation plates exclusively scalariform with 20–50 bars, or simple or both; interxylary phloem present in 2 genera; leaves mostly alternate, rarely opposite, simple, entire, rarely lobed or toothed, exstipulate; inflorescences axillary or leaf-opposed, usually cymose or thyriform, less frequently racemes, spikes or panicles; flowers usually bisexual, rarely the plants dioecious; sepals 4–5 (0), connate, small; petals 4–5 (0), free or rarely connate, valvate or imbricate; stamens 4–5, alternipetalous, the filaments free or the anthers sessile high on the corolla; pollen 4(5)-brevicolpate, 3-porate, 3(–6)-pororate, 3–7-brevicolporate, 3-colporoidate, or nonaperturate; disk rarely present; pistil 1, the carpels 3 (2–5), style 1, usually short, stigma(s) apical, sometimes capitate; ovary superior, usually unilocular, rarely

2–5-locular, the ovules usually 2 per locule, subapical, unitegmic, crassinucellar or tenuinucellar, anatropous; fruit usually a drupe, rarely a samara, the seed 1; embryo usually small, straight or arcuate, 0.2 the length of the endosperm; cotyledons sometimes foliaceous or folded, rarely thick, 2–9 times wider than the radicle, 0.8 the length of the embryo; endosperm mostly present, rarely 0, sometimes copious.

Composition: ~45 genera, ~400 species.

Distribution: Rain forest and dry habitats; pantropical, few subtropical.

CARYOPHYLLALES

Herbs, shrubs, rarely small trees, rarely climbing, often succulent, sometimes spiny; xylem vessel perforation plates simple, very rarely also reticulate; anomalous secondary thickening of the stem fairly frequent; leaves alternate or opposite, simple, entire, rarely toothed, sometimes rudimentary; flowers bisexual, rarely unisexual; perianth sometimes not differentiated into calyx and corolla, rarely spirally arranged and the parts numerous, free or rarely shortly connate; sepals 2–5 (0–25), free or shortly connate, often colored; petals 0, 4, 5 (2 to ~40) (staminodal?), in 1–6 whorls, rarely transitional to stamens, free or connate, sometimes inserted on the calyx tube; stamens 5–30 (1 to ~700), free or basally connate, rarely spirally arranged or in bundles, insertion hypogynous, perigynous or epigynous or on the base of the petals or on a glandular disk, the filaments often filiform, rarely very short, anthers dorsifixed or basifixed, sometimes pink; pollen 3-polycolpate, -rugate or -porate, 4-rupate; glandular disk often present; pistils 1 (–12), the carpels 1–5 (–20), styles 1–5 (–20, 0), the stigmas usually decurrent ventrally, sometimes apical; ovary superior to inferior, 1–5 (–20)-locular, the ovules 1–many per locule, axile, basal or parietal, usually campylotropous; fruit a berry, capsule, nutlet, drupe, achene, or schizocarp; embryo usually arcuate, peripheral to perisperm; perisperm, rarely endosperm, copious to absent.

Distribution: Cosmopolitan, most common in dry and disturbed habitats.

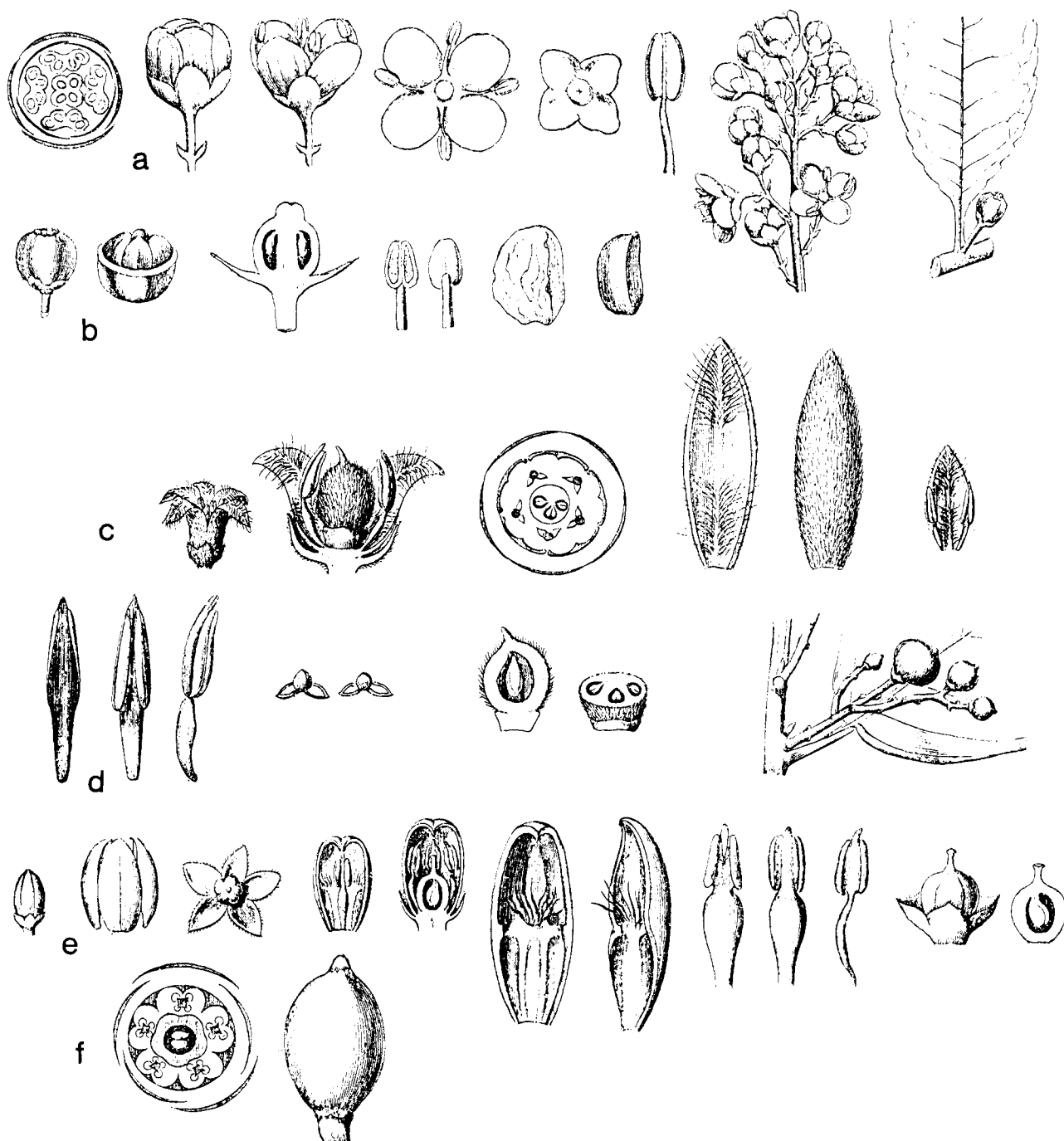


FIGURE 78.—AQUIFOLIACEAE: *a*, *Ilex paraguayensis* c.s. of bud, bud, flower, corolla and stamens, calyx, stamen, inflorescence, fruit in axil of leaf; *b*, fruit, c.s. of same showing the pyrenes, *I. loranthoides* l.s. of pistil, views of stamen, pyrene, seed (after Martius, 1840–1906). ICACINACEAE: *c*, *Emmotum nitens* flower, l.s. of same, floral diagram, views of petal, petal and 2 stamens; *d*, views of stamen, c.s. of anther, l.s. of pistil, c.s. of ovary, infructescence; *e*, *Poraqueiba sericea* bud, petals, calyx, 2 petals and stamen, l.s. of bud, views of petal, views of stamen, pistil and calyx, l.s. of pistil; *f*, floral diagram, fruit (after Martius, 1840–1906).

Chemistry: Betalains occur only in this order. According to Gibbs, except for lack of betalains, the Caryophyllaceae and Molluginaceae seem to fit reasonably well in the order. Triterpenoids, chiefly as saponins, occur in Phytolaccaceae, Molluginaceae, Caryophyllaceae, Chenopodiaceae, Amaranthaceae, and Cactaceae but not Polygonaceae, but triterpenoids are very widespread in plants. Betacyanins are probably absent from Polygonaceae. According to Gibbs, Cactaceae and Aizoaceae are often, and probably rightly, associated. Caryophyllales, except Caryophyllaceae, lack ellagic acid. *Fouquieria* has ellagic acid, which is lacking in the Tubiflorae; otherwise it fits well in that group. Ocotitol, a triterpenoid occurs in *Fouquieria* and *Neolloydia texensis*, a cactus. Gibbs believes the Bataceae and Polygonaceae are separate entities from this order and that chemically the Plantaginaceae fits very well in or near the Tubiflorae. It would be less happily placed as a derivative of the Primulales.

CACTACEAE (Figure 79a).—Spiny succulent herbs, shrubs, trees and scramblers; xylem vessel perforation plates simple, very rarely also reticulate; anomalous secondary thickening of the stem occurs in at least 2 genera; leaves usually rudimentary, sometimes well developed, simple, alternate, entire, exstipulate; flowers usually solitary, rarely in panicles, bisexual, rarely unisexual, the perianth usually not differentiated into calyx and corolla, spirally arranged, the tepals usually many, sometimes few, free or rarely basally connate, the floral tube containing nectar; stamens spirally arranged, numerous (~30–700), sometimes in groups, insertion perigynous or epigynous, sometimes adnate to the base of the petals, the filaments filiform; anthers small, about as long as wide, dorsifixed or basifixed; pollen 3-colpate, 6-polyrugate or forate; pistil 1, the carpels 2 to ~10, the style 1, stigmas 2 to ~10, slightly elongated and together broader than the apex of the style; ovary usually inferior and the receptacular tube often extending above the ovary, or rarely superior (*Pereskia*), unilocular, the ovules numerous to few, parietal or rarely

basal (*Pereskia* spp.), bitegmic, crassinucellar, anatropous to \pm campylotropous or circinotropous, the funicle often long; fruit a berry, rarely dry, rarely with longitudinal or circumscissile dehiscence, the seeds usually numerous; embryo often peripheral and arcuate, rarely straight; cotyledons 0.07–0.7 the length of the embryo, large and convolute in *Pereskia*, reduced in some genera and then the radicle expanded; perisperm generally floury-starchy, moderate, scanty or 0.

Composition: ~100 genera, ~2,000 species.

Distribution: Chiefly dry regions of warm temperate to tropical America; few high in the Andes or epiphytic in tropical forest; one species may be native in tropical west Africa, Madagascar, and Sri Lanka.

AIZOACEAE (Figure 79b,c).—Herbs and low shrubs, often succulent; xylem vessel perforation plates simple; anomalous secondary thickening of the stem occurs; leaves alternate or opposite, simple, usually entire, rarely toothed, usually exstipulate; inflorescences axillary or terminal pleiochasia, dichasia or the flowers solitary; flowers bisexual, rarely unisexual (*Glischrothamnus* is dioecious); calyx lobes 5–8; petals ~30–40 (staminodial?) or 0, in 1–6 whorls, sometimes transitional to stamens, sometimes connate, inserted on the calyx-tube; stamens numerous (to ~120), 4–5, 8 or 10, rarely 1, free or basally connate, sometimes in bundles, perigynous; anthers small, about as long as wide; pollen 3-colporoidate, occasionally 4-rupate or 4–6-rugate; disk often around the ovary; pistil 1, the carpels 2–5 (–20), sometimes weakly connate, the styles 1–5 (–20) or 0, stigmas apical or decurrent ventrally or sessile; ovary superior to inferior 2–5(1–20)-locular, the ovules (1-) several or many, axile, basal, or apical, bitegmic, crassinucellar, campylotropous or anacampylotropous, the funicle often long; fruit usually a capsule, mostly loculicidal, more rarely a septicidal schizocarp or circumscissile, sometimes a nut or drupe, rarely a berry (*Carpobrotus*); embryo peripheral, arcuate, as long as the perisperm to more than twice as long; cotyledons as wide as the radicle or slightly

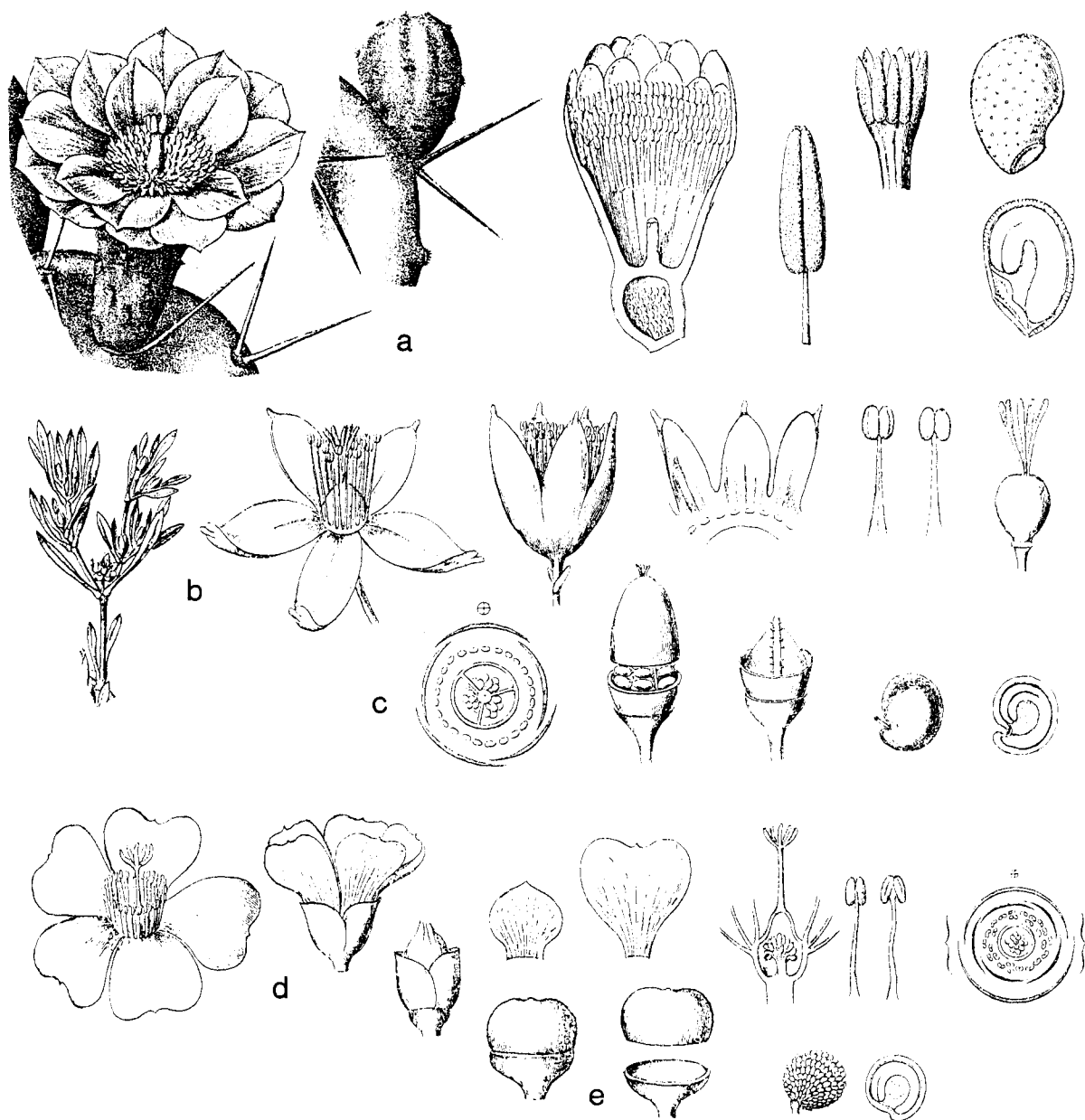


FIGURE 79.—CACTACEAE: *a*, *Opuntia monacantha* flower, fruit, *Cereus macrogonus* l.s. of flower (apex of style removed), anther, stigma, seed and l.s. of same (after Martius, 1840–1906). AIZOACEAE: *b*, *Sesuvium portulacastrum* flowering shoot, flower, lateral view of same, part of calyx laid open, views of stamen, pistil; *c*, floral diagram, dehiscent fruit, part of same, seed, l.s. of same. (after Martius, 1840–1906). PORTULACACEAE: *d*, *Portulaca elatior* flower, lateral view of same, sepals (2), sepal, petal, l.s. of pistil, views of stamen, floral diagram; *e*, fruit, dehiscent fruit, seed, l.s. of same (after Martius, 1840–1906).

wider, 0.4–0.5 the length of the embryo; perisperm moderate or copious, hard and semi-transparent or soft and whitish.

Composition: 130 genera, ~1200 species.

Distribution: Centered in the drier parts of South Africa, extending into eastern and western Africa; southern and western Australia, New Zealand; southwestern United States to northwestern Mexico; western middle South America; western, southern, and eastern Asia.

PORTULACACEAE (Figure 79*d,e*).—Herbs and subshrubs, often succulent; xylem vessel perforation plates simple; intraxylary phloem present in some genera; leaves alternate or opposite, sometimes rosulate, simple, entire, the stipules sometimes scarious, rarely 0 (*Claytonia*); inflorescences cymes, often dichasia to cincinni, panicles or heads or the flower solitary; flowers bisexual or very rarely the plants monoecious (*Portulacaria*) sepals (bracteoles?) 2 (5–8), free or basally connate; petals (tepals) 4–5 (2–16), free or basally connate; stamens 4–5 (1 to ~50), opposite the petals, the filaments filiform, free or rarely connate in bundles, occasionally adnate to the corolla; anthers small, often pink, about as long as wide, wall development conforms to the Monocot type; pollen 3-colpate, 6-polyrugate, polyforate; nectaries receptacular; pistil 1, the carpels 3 (2–8), the styles united most of the way, with 3 (2–8) apical linear branches, the stigmas decurrent ventrally, ovary superior, semi-inferior or inferior, septate when young, becoming unilocular, the ovules ∞ to 1, axile-basal, bitegmic, crassinucellar, anatropous, anacampylotropous, or amphitropous, the funicle sometimes long; fruit a capsule, dehiscence by apical valves or sometimes circumscissile, or a schizocarp, rarely a nut; seeds reniform; embryo peripheral, arcuate, more than twice as long as the perisperm; cotyledons about as wide as the radicle, 0.3–0.5 the length of the embryo; perisperm moderate or copious, rarely scanty, generally hard and semitransparent, sometimes soft and whitish.

Composition: 19 genera, ~540 species.

Distribution: Cosmopolitan except arctic re-

gion of the Northern Hemisphere, the Amazon basin, the Sahara, and part of the Australian deserts; centered in South Africa, western North America, and the Andes.

THELIGONACEAE (Figure 80*a,b*).—Succulent terrestrial herbs; xylem forms a continuous cylinder; leaves simple, entire, lower ones opposite, upper alternate; stipules attached to the petiole; plants monoecious, the flowers axillary in 1–3-flowered sessile cymes, anemophilous; calyx closed in bud, 2–5-partite at anthesis; petals 0; stamens 7–12 (2–30), the filaments filiform, free; anthers linear, dorsifixed; pollen 3–7-porate-brevicolpate; pistil 1, carpel 1, the style 1, filiform, stigma apical, punctiform; ovary superior (inferior according to some who see adnation to perianth), unilocular, uniovulate, the ovule basal, unitegmic, tenuinucellar, subanatropous or campylotropous; fruit a nutlet; seed hippocrepiform, the embryo axile, arcuate, about as long as the endosperm; cotyledons flat, thin, 2.3–5.5 times wider than the radicle, 0.5–0.6 the length of the embryo; endosperm copious, fleshy.

Composition: 1 genus, 3 species.

Distribution: Mediterranean region, southern Japan, western China, Canary Islands.

DIDIEREACEAE (Figure 80*c,d*).—Spiny trees and shrubs; xylem vessel perforation plates simple; leaves alternate, simple, entire, exstipulate; plants usually dioecious, rarely gynodioecious; inflorescences terminal dichasia or fascicles; sepals 2 (bracteoles?), petaloid; petals 4, in 2 series, free; stamens 8–10, the filaments filiform, shortly connate basally, inserted outside an annular disk; anthers oblong, didymous, dorsifixed; pollen 4–7-colpate; pistil 1, the carpels 3 (2–4), the style 1, stigma often expanded and 3–4-lobed; ovary superior, the locules 3 but only one fertile, ovule 1, basal, bitegmic, crassinucellar, campylotropous or hemicampylotropous; fruit a nutlet; seed arillate; embryo folded, the cotyledons about as long as the radicle; endosperm very scanty or 0.

Composition: 4 genera, 11 species.

Distribution: Semi-desert regions of Madagascar.

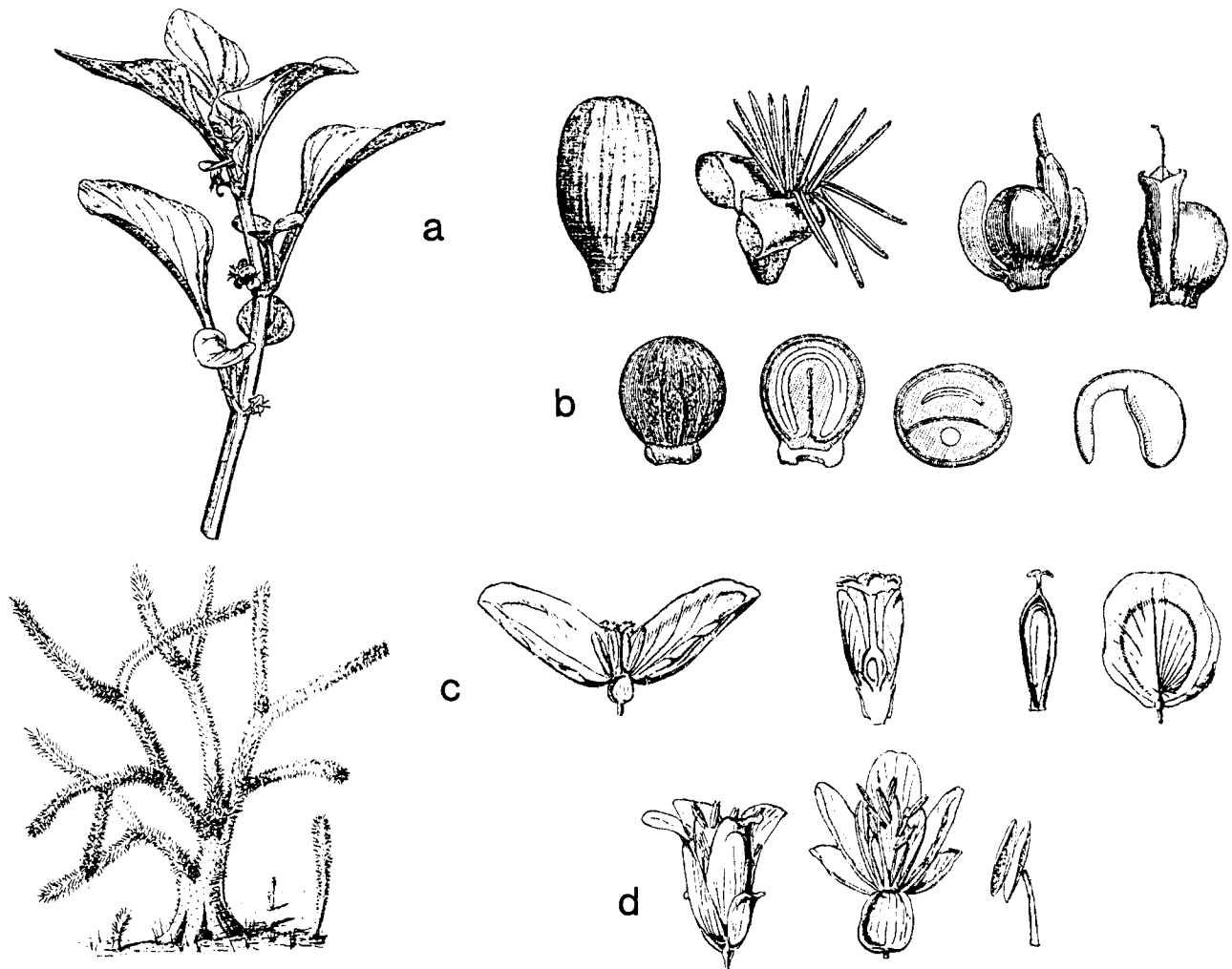


FIGURE 80.—THELIGONACEAE: *a*, *Theligonum cynocrambe* flowering shoot, ♂ flower bud, ♂ flower, young ♀ flower with bracteoles, mature ♀ flower; *b*, fruit, l.s. and c.s. of same, embryo (after Le Maout and Decaisne, 1873). DIDIEREACEAE: *c*, *Didierea mirabilis* habit, ♀ flower, l.s. of same, l.s. of pistil, fruit; *d*, ♂ flowers, stamen (after Drake).

GYROSTEMONACEAE (Figure 81a-c).—Trees and shrubs; xylem vessel perforation plates simple; stem without anomalous secondary thickening; leaves alternate, simple, entire, succulent, stipules rudimentary or absent; plants mostly dioecious, sometimes monoecious; inflorescences axillary racemes or spikes, or the flowers solitary; calyx 2–5-lobed or truncate; petals 0; stamens 6 to ~100 in 1 or more series; anthers oblong, subsessile; pollen 3-colpor(oid?)ate, receptacle broad; pistil 1, the carpels sometimes loosely

connate, mostly ∞ to 19, rarely as few as 2 or 1, the styles 1–19, stigmas apical, linear; ovary superior 19–1-locular, the ovules campylotropous, 1 per locule, axile; fruit dry, a capsule, or eventually falling apart, the parts dehiscent ventrally, dorsally or both, or rarely indehiscent; seeds hippocrepiform, arillate; embryo peripheral, longer than the perisperm (endosperm?); cotyledons not broadened, 0.4 the length of the embryo; perisperm (endosperm?) copious or scanty, fleshy.

Composition: 5 genera, 16 species.

Distribution: Most of Australia.

PHYTOLACCACEAE (Figure 81*d,e*).—Herbs, shrubs, rarely trees or scandent; xylem vessel perforation plates simple; anomalous secondary thickening of the stem occurs in some species; leaves alternate, simple, entire, exstipulate; inflorescences terminal, leaf-opposed or axillary spikes or racemes, rarely panicles; flowers bisexual or rarely the plants dioecious, the parts hypogynous; sepals 4–10, free, green or colored; petals 0; stamens 5–30, in 1 or 2 series, the filaments filiform, free or basally connate, sometimes inserted on a fleshy disk; anthers small, about as long as wide, dorsifixed; pollen 3-colpate, 4-rupate; pistils 4–12, sometimes \pm connate, the styles 4–12, free or basally connate, stigmas ventrally decurrent; ovary 4–12-locular, the ovules 1 per locule, bitegmic, crassinucellar, amphio-, anacampylo-, or campylotropous, basal-ventral; fruit a berry or drupe; seeds \pm reniform, the embryo peripheral, arcuate; cotyledons 1–1.5 times the width of the radicle, 0.4 the length of the embryo; perisperm moderate or copious, soft or granular and whitish.

Composition: 12 genera, 100 species.

Distribution: Centered in tropical and subtropical America, extending to temperate America; southern $\frac{2}{3}$ of Africa; eastern Mediterranean region; Japan to India and the East Indies, north-eastern Australia.

BARBEUIACEAE (Figure 81*f*).—Shrubby tree, sarmentose; xylem vessel perforation plates simple; stem with anomalous secondary thickening; leaves alternate, simple, entire, exstipulate; inflorescence short axillary racemes; flowers bisexual, the parts hypogynous; sepals 5, free; petals 0; stamens numerous (~50–60), in several series, the filaments inserted on an annular disk; anthers linear, sagittate, basifixed; pollen 3-colporoidate, occasionally 4-ruporoidate or 6-rugoroidate; pistil 1, the carpels 2, the styles 2, linear, very shortly connate, the stigmas decurrent ventrally; ovary bilocular, the ovules 1 per locule, basal, campylotropous; fruit a woody capsule, the seeds reniform, arillate; embryo arcuate, axile, about

as long as the endosperm; cotyledons not broadened, 0.4 the length of the embryo; endosperm (perisperm?) copious, mealy.

Composition: 1 genus, 1 species.

Distribution: Madagascar.

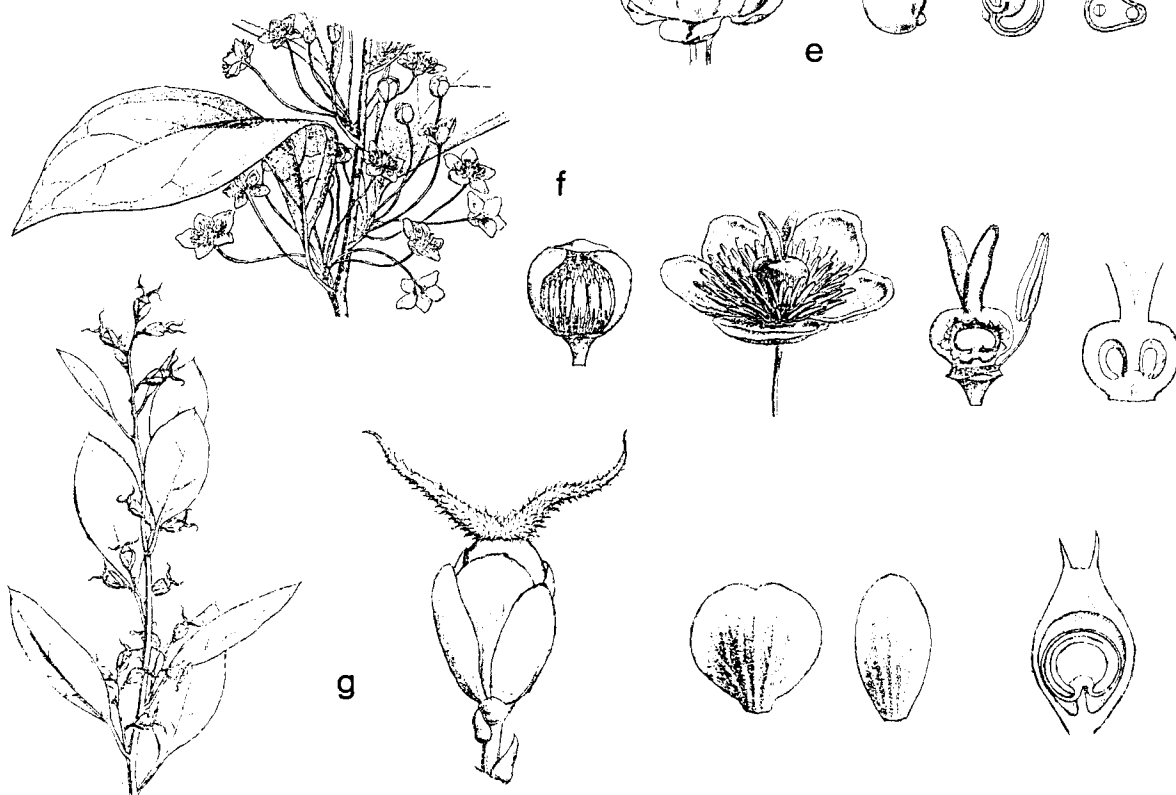
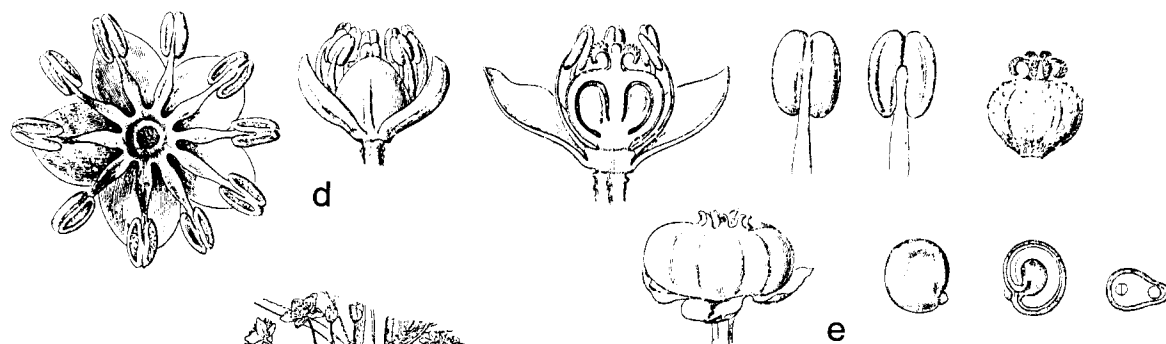
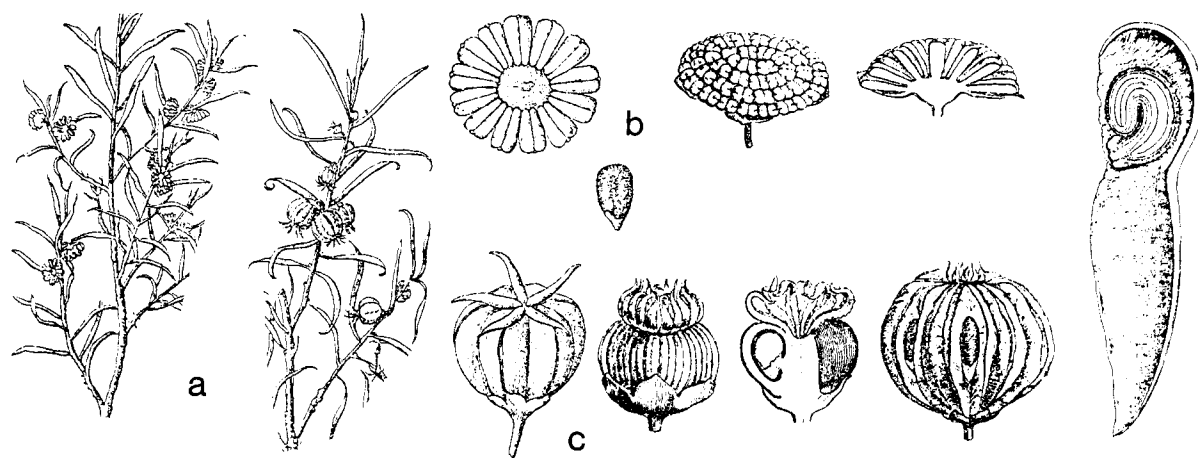
ACHATOCARPACEAE (Figure 81*g*).—Trees and shrubs, sometimes thorny; xylem vessel perforation plates simple; stem without anomalous secondary thickening; leaves alternate, simple, entire, exstipulate; inflorescences axillary or cauliflorous racemes, short panicles, or fascicles; plants dioecious, the flower parts hypogynous; sepals 4–5, imbricate, free or very shortly connate, persistent; petals 0; stamens 10–20, the filaments filiform, shortly connate; anthers oblong, basifixed; pollen 6-polyforate or 3-colpate; pistil 1, the carpels 2, the styles 2, short, free, the stigmas decurrent ventrally; ovary unilocular, ovule 1, basal, campylotropous; fruit a berry, the seed exarillate; embryo peripheral, arcuate, about 2.5 times longer than the perisperm; cotyledons not broadened, 0.5–0.6 the length of the embryo; perisperm copious.

Composition: 2 genera, 10 species.

Distribution: Texas and Mexico to Paraguay and Argentina.

PETIVERIACEAE (Figure 82*a*).—Shrubs, lianas, and herbs; xylem vessel perforation plates simple; stem with anomalous secondary thickening; leaves alternate, simple, entire or rarely crenate, the stipules small or 0; inflorescences axillary and

FIGURE 81.—GYROSTEMONACEAE: *a*, *Gyrostemon australasicus* ♂ flowering branch, ♀ flowering and fruiting branch; *b*, ♂ flower, seed, *G. ramulosus* ♂ flower, l.s. of same; *c*, *G. australasicus* fruit, *G. ramulosus* ♀ flower, l.s. of same, dehiscent fruit, *Codonocarpus pyramidalis* l.s. of fruitlet (after Walter; Baillon, 1866–1895). PHYTOLACCACEAE: *d*, *Phytolacca thyrsiflora* ♂ flower from above, flower not fully open, l.s. of flower, views of anther, pistil; *e*, fruit with perianth, seed, l.s. and c.s. of same (after Martius, 1840–1906). BARBEUIACEAE: *f*, *Barbeuia madagascariensis* part of flowering twig, bud with 2 tepals removed, flower, pistil with ovary opened to show ovule and 1 stamen, l.s. of ovary (after Baillon, 1866–1895). ACHATOCARPACEAE: *g*, *Achatocarpus bicornutus* flowering twig, young fruit, *A. balansae* interior tepal, external tepal, *A. praecox* l.s. of fruit (after Schinz and Autran).



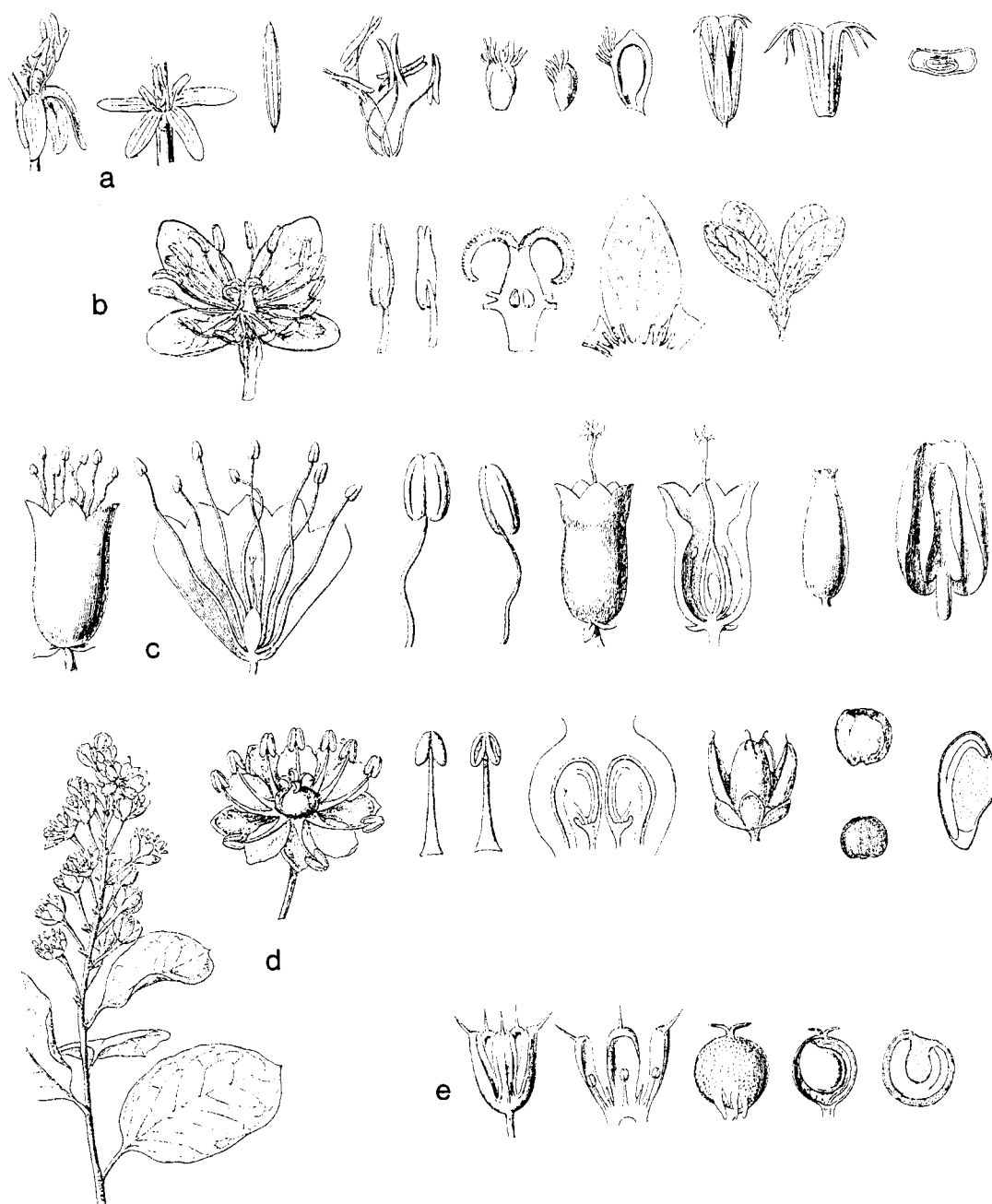


FIGURE 82.—PETIVERIACEAE: *a*, *Petiveria hexaglochin* 2 views of flower, tepal, stamens, views of pistil, l.s. of same, fruit with and without perigone, c.s. of fruit showing embryo (after Martius, 1840–1906). AGDESTIDACEAE: *b*, *Agdestis clematidea* flower, views of stamen, l.s. of ovary, part of perianth and base of stamens, ripe fruit with persistent perianth (after Hemsley). NYCTAGINACEAE: *c*, *Pisonia tomentosa* ♂ flower, same laid open, views of stamen, ♀ flower, l.s. of same, fruit enclosed in perigone, embryo (after Martius, 1840–1906). STEGNOSPERMATACEAE: *d*, *Stegnosperra halimifolium* flowering twig, flower, views of stamen, l.s. of ovary, dehiscent fruit, seed enclosed in aril and without aril, l.s. of seed (after Fawcett and Rendle; Walter). ILLECEBRACEAE: *e*, *Paronychia brasiliiana* flower, part of perianth laid open, fruit, l.s. of ovary, l.s. of seed (after Martius, 1840–1906).

terminal racemes, panicles or spikes; flowers bisexual or rarely the plants dioecious, the parts hypogynous; sepals 4–5, sometimes shortly connate; petals 0; stamens 4–25, the filaments free or shortly connate; anthers oblong, dorsifixed or basifixed; pollen 3-colpate or 6-polyrugate or polyforate; disk present or absent; pistil 1, the carpels 1–5, the styles 1–5, stigmas decurrent; ovary unilocular, the ovule 1, basal, bitegmic, crassinucellar, campylotropous; fruit a berry, samara, or spiny nutlet; embryo peripheral, arcuate or straight, the cotyledons thin, foliaceous, convolute about the upper part of the radicle; perisperm moderate, hard and semitransparent.

Composition: 6 genera, 10 species.

Distribution: Warm temperate to tropical America.

AGDESTIDACEAE (Figure 82b).—Twining herb, liana, or subshrub; xylem vessel perforation plates simple; stem with anomalous secondary thickening; leaves alternate, simple, entire, exstipulate; inflorescences axillary loose panicles of cymes, the flowers bisexual; sepals 4–5, very shortly connate or free, accrescent; petals 0; stamens 15–20, in more than 1 series, the filaments filiform, inserted on a disk; anthers dorsifixed near the base; pollen 3-colpate; pistil 1, the carpels 3–4, the styles shortly connate, 3–4-fid and linear apically, the stigmas decurrent ventrally; ovary semi-inferior, 3–4-locular, the ovules 1 per locule, axile, subbasal, campylotropous; fruit a unilocular 1-seeded nutlet, winged by the calyx lobes; seed exarillate, the embryo peripheral, arcuate, the cotyledons broadly oblong, the radicle short; perisperm scanty, mealy.

Composition: 1 genus, 1 species.

Distribution: Mexico to Brazil, West Indies.

NYCTAGINACEAE (Figure 82c).—Shrubs, trees, herbs, and lianas, sometimes thorny; xylem vessel perforation plates simple, occasionally also reticulate; stem with anomalous secondary thickening; interxylary phloem in some genera; leaves alternate or opposite, simple, entire, exstipulate; inflorescences various, cymose, very rarely a raceme (*Cyphomeris*); flowers bisexual or unisexual, rarely the plants dioecious (*Cephalotomandra*),

the parts hypogynous; bracts sometimes colored; calyx tubular, often petaloid, the lobes 5 (3–7); petals 0; stamens 5 (1–30), sometimes in 2 whorls, the filaments filiform, free or shortly connate, rarely adnate to the calyx-tube; anthers dorsifixed near the base; pollen 3(4)-colpate, 6-polyrugate or polyforate; pistil 1, the carpel 1 (rarely a flower with 2 pistils ventrally connected), the style filiform, stigma apical, rarely the stigma sessile (*Reichenbachia*) or decurrent ventrally (*Ramisia*); ovary unilocular, ovule 1, basal, 1–2-tegmic, crassinucellar, anacampylo- or campylotropous or subanatropous; fruit an achene or nutlet, enclosed by the base of the calyx; embryo peripheral, arcuate or rarely straight, twice as long as the perisperm; cotyledons often unequal, rarely reduced to 1, thin, rarely longitudinally convolute, 3–9 times wider than the radicle, 0.5 the length of the embryo; perisperm copious, moderate, or rarely scanty, crystalline-granular, rarely whitish and mealy or whitish and hard.

Composition: 30 genera, ~290 species.

Distribution: Mainly pantropical and subtropical, particularly America; temperate North America to temperate South America, Africa, southern Asia, Australia, New Zealand.

STEGNOSPERMACEAE (Figure 82d).—Shrub, sometimes scandent; xylem vessel perforation plates simple; stem without anomalous secondary thickening; leaves alternate, simple, entire, fleshy, exstipulate; inflorescence a terminal raceme or thyrses or axillary cymes; flowers bisexual, the parts hypogynous; sepals 5, free, persistent; petals 5, free; stamens 10, the filaments filiform, shortly connate; anthers about as long as wide, dorsifixed; pollen 3-colpate; pistil 1, the carpels 3–5, the styles short, linear, shortly connate, the stigmas decurrent ventrally; ovary unilocular with a central column, the ovules 3–5, basal, amphitropous; fruit a capsule, the valves separating to the base; seeds with a large red aril; embryo peripheral, arcuate, 1.3 times longer than the perisperm; cotyledons not broadened (?), 0.7 the length of the embryo; perisperm copious, mealy.

Composition: 1 genus, 3 species.

Distribution: Dry or coastal regions; Mexico, Central America, West Indies.

CARYOPHYLLACEAE (Figure 83a,b).—Herbs, subshrubs, rarely shrubs, the stems often swollen at the nodes; xylem vessel perforation plates simple; stem and roots of some genera with anomalous secondary thickening; leaves opposite, simple, entire, stipules absent or present and then often scarious; inflorescences usually terminal, paniculate, racemiform or capitate dichasial cymes or cincinni, or the flowers solitary; flowers bisexual or rarely the plants dioecious (*Sanctambrosia*, *Melandrium dioicum*), the parts hypogynous, rarely slightly perigynous; sepals 5 (4–25), rarely spirally arranged, free or connate; petals 5 (4–12) or 0, free; stamens 10 (3–13), usually in 2 series, mostly obdiplostemonous, the filaments filiform, free; anthers about as long as wide, dorsifixed; pollen 3-colpate, polyforate; glands at the base of the stamens or disk present; pistil 1, the carpels 2–5 (6), the styles 2–5 (6), filiform, free or shortly connate, rarely mostly connate, the stigmas decurrent ventrally; ovary unilocular or imperfectly 2–5-locular, the ovules mostly numerous to only 1, bitegmic, crassinucellar, usually campylotropous, or semi-anatropous, the placenta free-central, axile or basal; fruit a capsule, dehiscent by apical teeth or by valves, rarely circumscissile (*Drypis spinosa*), or rarely a scarcely fleshy berry (*Cucubalus*); seeds usually numerous (1(2) in *Drypis spinosa*); embryo peripheral, arcuate to spiral (*Drypis*), or straight (*Dianthus*), 1–3 times as long as the perisperm; cotyledons 1–2 times as broad as the radicle, 0.5 the length of the embryo; perisperm moderate, copious or absent, usually firm or hard and semitransparent, rarely soft and white.

Composition: 55 genera, 1550 species.

Distribution: Cosmopolitan, mainly temperate Northern Hemisphere, centered in the Mediterranean region, sparingly arctic, antarctic, and in the mountains of the tropics.

MOLLUGINACEAE (Figure 83c).—Herbs and subshrubs, rarely shrubs; stems and roots with anomalous secondary thickening; leaves opposite, alternate or subverticillate, simple, entire, slightly or not succulent, the stipules scarious,

small or 0; inflorescences pleiochasial or dichasial cymes, or in glomerules to cincinni, or the flowers solitary; flowers bisexual; sepals 5, mostly free, rarely shortly connate; petals typically 0, sometimes 4–5, free or rarely connate (*Corbichonia*); stamens 5–10 (many in *Corbichonia*), the filaments filiform, free or shortly connate, sometimes in bundles, insertion hypogynous or slightly perigynous; anthers slightly longer than wide, dorsifixed; pollen mainly tricolpate; disk absent or annular; pistil 1 (except *Gisekia*), the carpels 2–5, the styles 2–5, or sometimes the stigmas sessile; ovary superior, 2–5-locular, the ovules 1 per locule and basal, or numerous and axile, bitegmic, crassinucellar, campylotropous to almost anatropous (*Macarthuria* and *Mollugo* ?); fruit a loculicidal or circumscissile capsule, rarely a nutlet or schizocarp; seeds sometimes arillate; embryo peripheral, arcuate, about twice as long as the perisperm; cotyledons not broadened, 0.4 the length of the embryo; perisperm moderate to copious, hard and semitransparent.

Composition: 14 genera, 95 species.

Distribution: Mostly tropical and subtropical, in dry habitats, few temperate; centered in Africa.

ILLECEBRACEAE (Figure 82e).—Herbs, rarely subshrubs, xylem vessel perforation plates simple; leaves mostly opposite, rarely some alternate, simple, mostly entire, the stipules scarious, sometimes connate, rarely absent; bracts often scarious; flowers bisexual or rarely unisexual, solitary or in cymes(?); sepals 4–5, free or shortly connate; petals 0 or 4–5; stamens 3–5, rarely fewer or more, mostly perigynous, the filaments free or shortly connate; anthers about as long as wide, dorsifixed, the sacs separate; pollen 3-porate, 3-colpate, 6-polyforate; pistil 1, the carpels (1) 2–3, the styles 1–3, free, the stigmas terminal(?); ovary superior, unilocular, ovule 1 (2–4), basal, bitegmic, crassinucellar, semi-anatropous; fruit a utricle or nutlet, 1-seeded; embryo peripheral, straight to nearly annular; cotyledons 1–1.5 times the width of the radicle, 0.4–0.6 the length of the embryo; perisperm copious to scanty, usually hard and transparent.

Composition: 15 genera, 200 species.

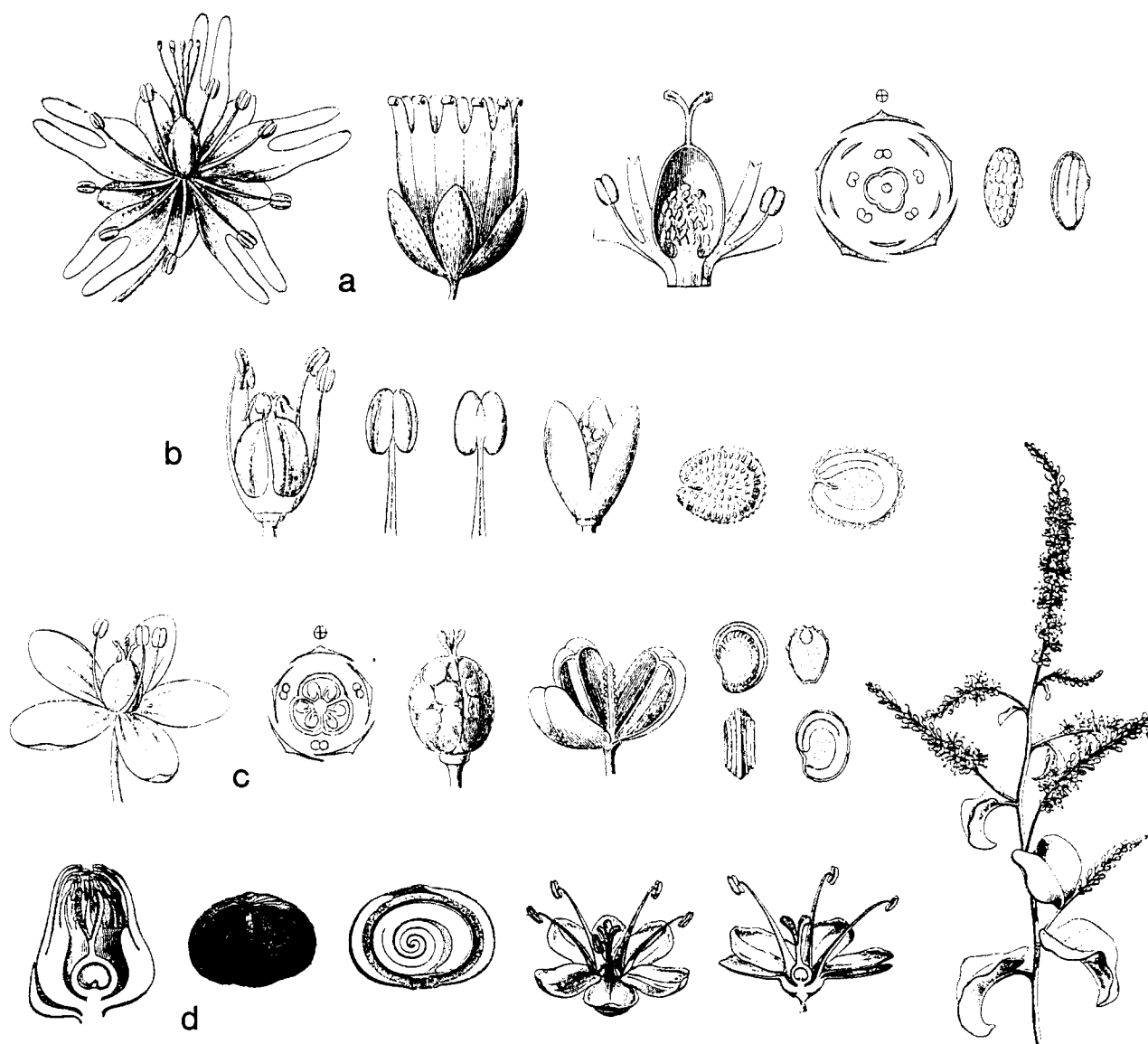


FIGURE 83.—CARYOPHYLLACEAE: *a*, *Cerastium humifusum* flower, dehiscent fruit with calyx, *Polycarpon depressum* l.s. of flower, floral diagram, seed, l.s. of same; *b*, *Drymaria cordata* essential organs, views of stamen, dehiscent fruit, seed, l.s. of same (after Martius, 1840–1906). MOLLUGINACEAE: *c*, *Mollugo verticillata* flower, floral diagram, fruit, dehiscent fruit, 2 views of seed, c.s. and l.s. of same (after Martius, 1840–1906). BASELLACEAE: *d*, *Basella rubra* l.s. of flower, fruit, l.s. of same, *Anredera baselloides* flower, l.s. of same, flowering shoot (after Baillon, 1866–1895).

Distribution: Cosmopolitan, most common in drier habitats.

BASELLACEAE (Figure 83d).—Herbaceous twiners or procumbent; xylem vessel perforation plates simple; stem without anomalous secondary thickening, but with bicollateral bundles in old

stems(?); leaves alternate, simple, entire, often fleshy, exstipulate; inflorescences axillary or supra-axillary spikes, racemes or panicles; flowers bisexual, rarely unisexual; sepals 5, nearly free to connate in a tube, often colored; petals 0; stamens 5, the filaments short, connate basally

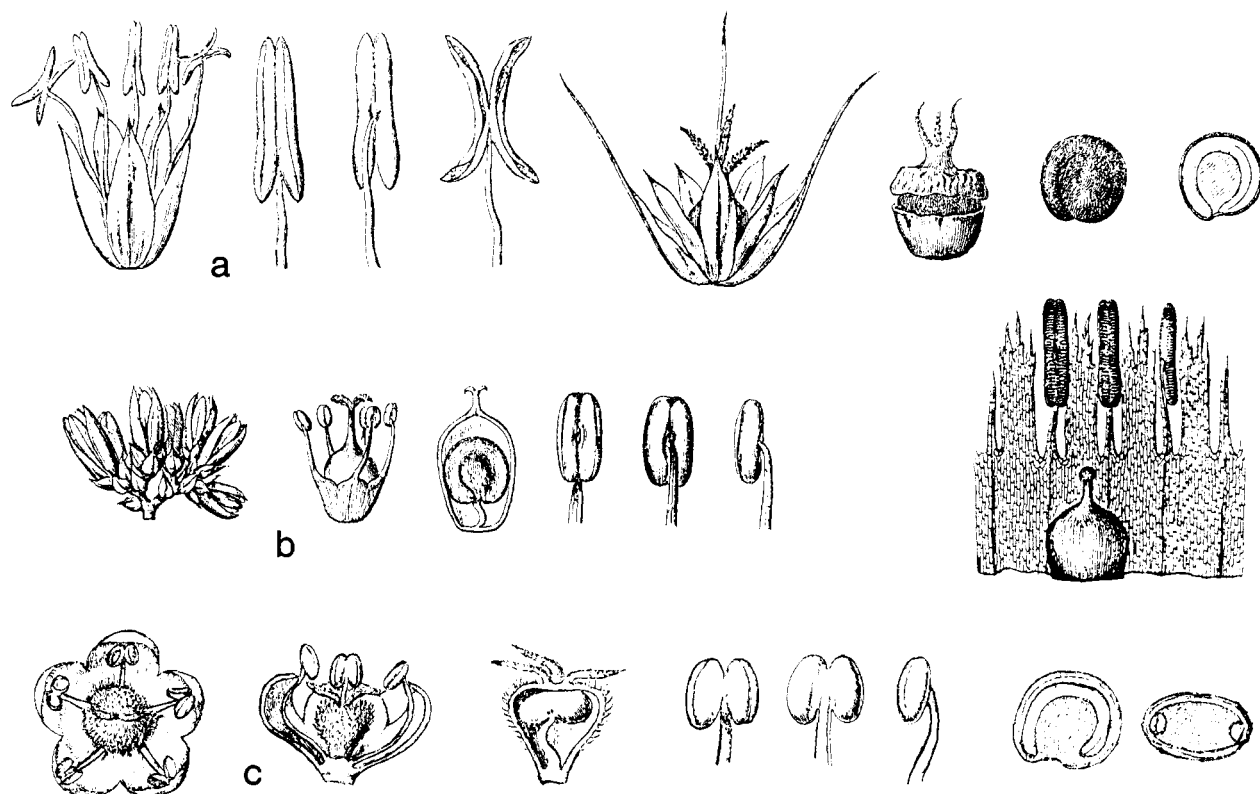


FIGURE 84.—AMARANTHACEAE: *a*, *Amaranthus hypochondriacus* ♂ flower, views of stamen, ♀ flower, dehiscent fruit, seed, l.s. of same; *b*, *Indobanalia brasiliensis* inflorescence, essential organs, l.s. of fruit, views of anther, *Alternanthera philoxeroides* staminal tube laid open and pistil (after Martius, 1840–1906). CHENOPODIACEAE: *c*, *Chenopodium retusum* flower, l.s. of same, l.s. of ovary, views of anther, *C. spathulatum* l.s. and c.s. of seed (after Martius, 1840–1906).

or inserted on the base of the sepals and opposite them; anthers about as long as wide, dorsifixed, rarely basifixed, reversed in bud, usually dehiscent by apical pores or pore-like slits; pollen 6-polyrugate or forate or transitional between them; annular disk sometimes present; pistil 1, the carpels 3, the style 1, often 3-lobed, rarely unlobed, the stigmas apical or decurrent; ovary superior, unilocular, ovule 1, basal, bitegmic, crassinucellar, anatropous, anacampylo- or campylotropous; fruit a berry or drupe; embryo peripheral, arcuate to subannular, or spirally twisted; cotyledons plano-convex or subfoliaceous, 0.5–0.7 the length of the embryo; perisperm copious or scanty.

Composition: 4 genera, ~25 species.

Distribution: Tropical and subtropical, mostly America; Africa, Madagascar, southern India, New Guinea.

AMARANTHACEAE (Figure 84*a,b*).—Herbs, rarely shrubs or small trees; xylem vessel perforation plates simple; stem and roots with anomalous secondary thickening; leaves alternate or opposite, simple, entire, exstipulate; inflorescences terminal and axillary spikes, heads, racemes or cymes, glomerules, dichasia or cincinni; flowers usually bisexual, rarely the plants polygamous or dioecious, the parts hypogynous (stamens perigynous in *Guilleminea*); bracts and bracteoles often scarious; sepals (0–1) 3–5, free or shortly connate, scarious; petals 0; stamens 5 (1–4), often alternate with staminodial membranes,

the filaments free or connate, sometimes inserted on the calyx or disk; anthers small, dorsifixed; pollen 6-polyforate; disk present or absent; pistil 1, the carpels 2–3, the styles 1–3, the stigmas decurrent or apical; ovary unilocular, the ovules 1–few, basal, bitegmic, crassinucellar, campylo- or anacampylotropous or circinotropous; fruit a pyxis, nutlet or berry; embryo peripheral, subannular; cotyledons 1–1.5 times the width of the radicle, 0.5–0.7 the length of the embryo; perisperm copious, hard and translucent to granular and whitish.

Composition: 65 genera, ~850 species.

Distribution: Cosmopolitan except for arctic Northern Hemisphere; many in tropical Africa and America.

CHENOPODIACEAE (Figure 84c).—Herbs and shrubs, rarely small trees or climbers; xylem vessel perforation plates simple or very rarely with some oblique scalariform perforations (*Axyris*); stem and roots with anomalous secondary thickening; interxylary phloem typical; leaves mostly alternate, rarely opposite, simple, sometimes fleshy or reduced to scales, entire or toothed, exstipulate; inflorescences axillary and terminal heads, spikes, thyrses, dichasia or cincinni, or flowers rarely solitary; flowers minute, bisexual or the plants monoecious or dioecious; sepals 3–5 (0–4), free or connate, sepaloid or membranous, often accrescent; petals 0; stamens 3–5 (1, 2) and opposite the calyx lobes, hypogynous or inserted on a disk or on the calyx, the filaments usually free, sometimes shortly connate; staminodes rare; anthers dorsifixed, incurved in bud, rarely with a large apical connective appendage; pollen (oligo-) polyforate; disk present or absent; pistil 1, the carpels 2 (3–5), the styles 2 (1–5), short, the stigmas decurrent ventrally or all over; ovary superior, rarely semi-inferior (*Beta*), unilocular, ovule 1, basal, bitegmic, crassinucellar, campylotropous or amphitropous; fruit a nutlet or achene, rarely a pyxis or berry; embryo peripheral, arcuate, annular or coiled, as long as to more than twice as long as the perisperm, sometimes conduplicate and the radicle incumbent;

cotyledons 1–2 times the width of the radicle, 0.5 the length of the embryo; perisperm copious to absent, usually firm to flinty and glass-like to whitish.

Composition: 102 genera, ~1500 species.

Distribution: Principally in desert, saline and disturbed habitats; cosmopolitan.

PRIMULALES

Herbs, shrubs, and small trees, rarely climbing; xylem vessel perforation plates simple, a few species of Myrsinaceae also with scalariform plates; stem sometimes with anomalous secondary thickening, sometimes resinous; leaves opposite or alternate, simple, entire or toothed, exstipulate; flowers bisexual, rarely unisexual, sometimes heterostyled; sepals 4–5 (3, 6–9), free or connate; petals 4–5 (0, 3, 6–9), usually connate; stamens 4–5 (to ~75 in Tamaricaceae), free, shortly connate or epipetalous opposite the corolla lobes when in one series, rarely 5 (4) staminodes present; anthers dorsifixed, rarely basifixed; pollen usually 3(2–5)-colporate, less often 3–10-colpate, 4-rupate or 6-rugate; glandular disk sometimes present; pistil 1, the carpels 5 (2–9), styles 1 (5), the stigma(s) apical, more rarely decurrent ventrally or sessile; ovary superior, rarely semi-inferior, unilocular, the ovules 1-many, basal or the placenta free-central, more rarely parietal; fruit a capsule, berry or drupe, rarely a nutlet; embryo straight, often cylindrical; endosperm copious to absent.

Distribution: Cosmopolitan.

Chemistry: Triterpenoid saponins are prevalent in the order. Alkaloids are virtually absent. Gibbs feels a close association between Plumbaginaceae and Primulales is justified. Plumbaginaceae and Droseraceae have plumbagin, a naphthaquinone. Plumbaginaceae lack betalains. Primulaceae lack betacyanins.

PRIMULACEAE (Figure 85a,b).—Herbs, rarely subshrubs; xylem vessel perforation plates simple; stem sometimes with anomalous structure (concentric rings of bundles); tissues often with

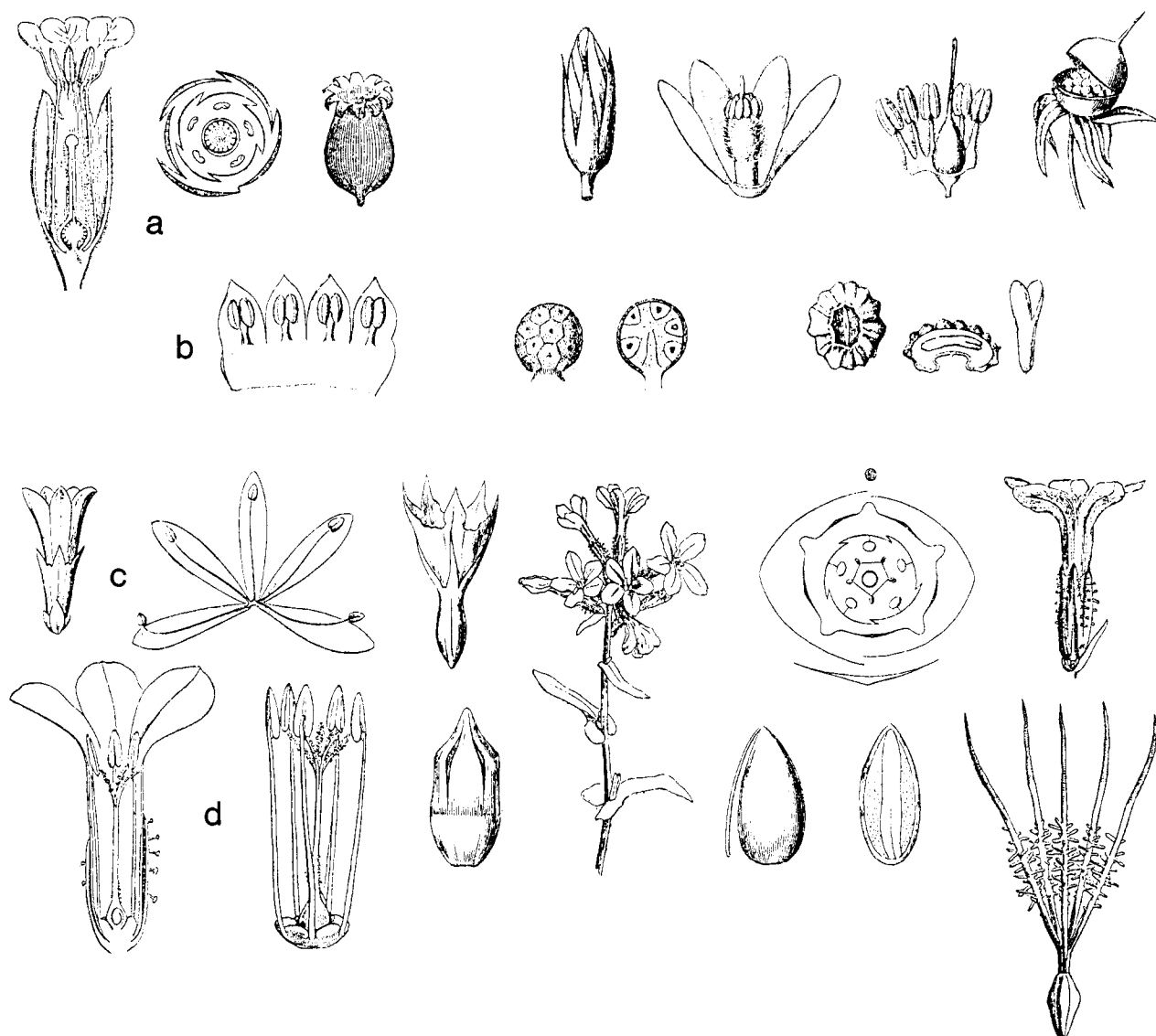


FIGURE 85.—PRIMULACEAE: *a*, *Primula officinalis* l.s. of flower, floral diagram, dehiscent fruit, *Anagallis tenella* bud, corolla (1 segment removed) and staminal tube and apex of style, staminal tube laid open to show the pistil, dehiscent fruit; *b*, *A. minimus* corolla laid open to show the insertion of the stamens opposite the petals, *A. latifolia* placenta and l.s. of same showing insertion of seeds, *Pelletiera vera* seed, l.s. of same, embryo (after Martius, 1840–1906; Le Maout and Decaisne, 1873). PLUMBAGINACEAE: *c*, *Limonium brasiliense* flower, corolla laid open to show insertion of stamens opposite the petals, calyx in fruit, *Plumbago europaea* flowering shoot, *P. scandens* floral diagram, *P. europaea* flower; *d*, l.s. of flower, essential organs, fruit, seed, l.s. of same, *Armeria* sp. pistil (after Martius, 1840–1906; Le Maout and Decaisne, 1873).

secretory cells and spaces; leaves basal or cauline, usually opposite or verticillate, sometimes alternate, simple, often glandular-punctate, entire or toothed and lobed or divided (*Hottonia*), exstip-

ulate; inflorescences terminal umbels, racemes, panicles, or the flowers solitary; flowers bisexual, often heterostyled, rarely slightly zygomorphic; sepals 5 (4–9), connate; petals 5 (4–9), (0 in

Glaux), connate, sometimes only shortly so or separate (*Pelletiera*), rarely unguiculate; stamens 5 (4–9), the filaments long or short, free or basally connate, or epipetalous and opposite the corolla lobes, rarely alternating with staminodes (scales); anthers dorsifixed; pollen 3(2–4)-colporate or colpoidate, or 3–10-colpate; pistil 1, the carpels 5 (4–9), the style 1, stigma apical, capitate, simple; ovary superior, rarely semi-inferior, unilocular, the ovules few to numerous, basal or free-central, 2(1)-tegmic, tenuinucellar, anatropous, semi-anatropous, or campylotropous; fruit a capsule, dehiscent usually by apical teeth, or by valves, rarely circumscissile, rarely subindehiscent, the seeds angular, sometimes minute; embryo linear, straight, terete, 0.4–0.9 the length of the endosperm; cotyledons 1–1.7 times the width of the radicle, 0.2–0.5 the length of the embryo; endosperm copious, hard or firm, semitransparent.

Composition: ~25 genera, ~900 species.

Distribution: Cosmopolitan, centered in temperate Northern Hemisphere; many alpine, a few on shores.

PLUMBAGINACEAE (Figure 85*c,d*).—Herbs, subshrubs, or climbers; xylem vessel perforation plates simple; stem often with cortical and medullary vascular bundles and occasionally anomalous secondary thickening; leaves alternate, sometimes rosulate, simple, entire, exstipulate; inflorescences terminal or axillary spikes, racemes, panicles, subumbels, sometimes involucrate heads, or dichasia; flowers bisexual, sometimes heterostyled (*Limonium*); bracts often sheathing and scarious; sepals 5, connate most of the way, the limb sometimes scarious; petals 5, connate, sometimes shortly so, contorted and imbricate in bud; stamens 5, elongated, free or basally connate, or epipetalous, opposite the corolla lobes; anthers oblong, dorsifixed; pollen 3–5-colpate, 4-rupate, 6-rugate; disk absent; pistil 1, the carpels 5, the styles 5, filiform, or 1 and shortly 5-lobed apically, the stigmas decurrent ventrally, sometimes for the entire length of the style, or capitate; ovary superior, unilocular, ovule 1, basal, bitegmic, crassinucellar, circino-

tropous or anatropous, the funicle long; fruit a nutlet or capsule at length circumscissile, rarely valvate from the base; embryo straight, 0.9 to as long as the endosperm; cotyledons thin or moderately thick, 2–3 times the width of the radicle, 0.4–0.9 (*Aegialitis* 0.2) the length of the embryo; endosperm scanty, moderate or 0, firm crystalline-granular, floury, or fleshy.

Composition: ~15 genera, ~700 species.

Distribution: Most commonly in dry or saline habitats; cosmopolitan, centered in the Mediterranean region, western and central Asia.

TAMARICACEAE (Figure 86*a–c*).—Shrubs, trees, and herbs; xylem vessel perforation plates simple; leaves alternate, simple, scale-like or small, entire, exstipulate; inflorescences spikes, racemes, or the flowers solitary; flowers bisexual, rarely unisexual, the plants dioecious in *Tamarix dioica*, the parts hypogynous; sepals 4–5 (6), free or connate; petals 4–5 (6), free, sometimes with 2 ligular processes; stamens 4–10 (to ~75), mostly obdiplostemonous, the filaments filiform, free or basally connate, inserted on a disk; anthers small, slightly longer than wide, versatile; pollen 3(2–4)-colpate, simple or in tetrads; pistil 1, the carpels 3 (2–5), the styles 3 (2–5), sometimes nearly absent, free or basally connate, the stigmas apical or decurrent ventrally; ovary unilocular, the ovules 2–many, parietal or basal, bitegmic, crassi- or ± tenuinucellar, anatropous; fruit a loculicidal capsule; seeds usually with long hairs, sometimes winged; embryo straight, 0.7–0.8 the length of the endosperm, the cotyledons 0.4–0.5 the length of the embryo; endosperm moderate or 0.

Composition: 4 genera, ~100 species.

Distribution: Chiefly temperate and subtropical, commonly steppe, desert, and shore plants, centered in the Mediterranean region and extending to eastern Asia; southern and southwestern Africa; Norway.

FRANKENIACEAE (Figure 86*d,e*).—Herbs and small shrubs of saline habitats, the stems sometimes jointed; xylem vessel perforation plates simple; leaves opposite, simple, entire, exstipulate; inflorescences terminal and axillary di-

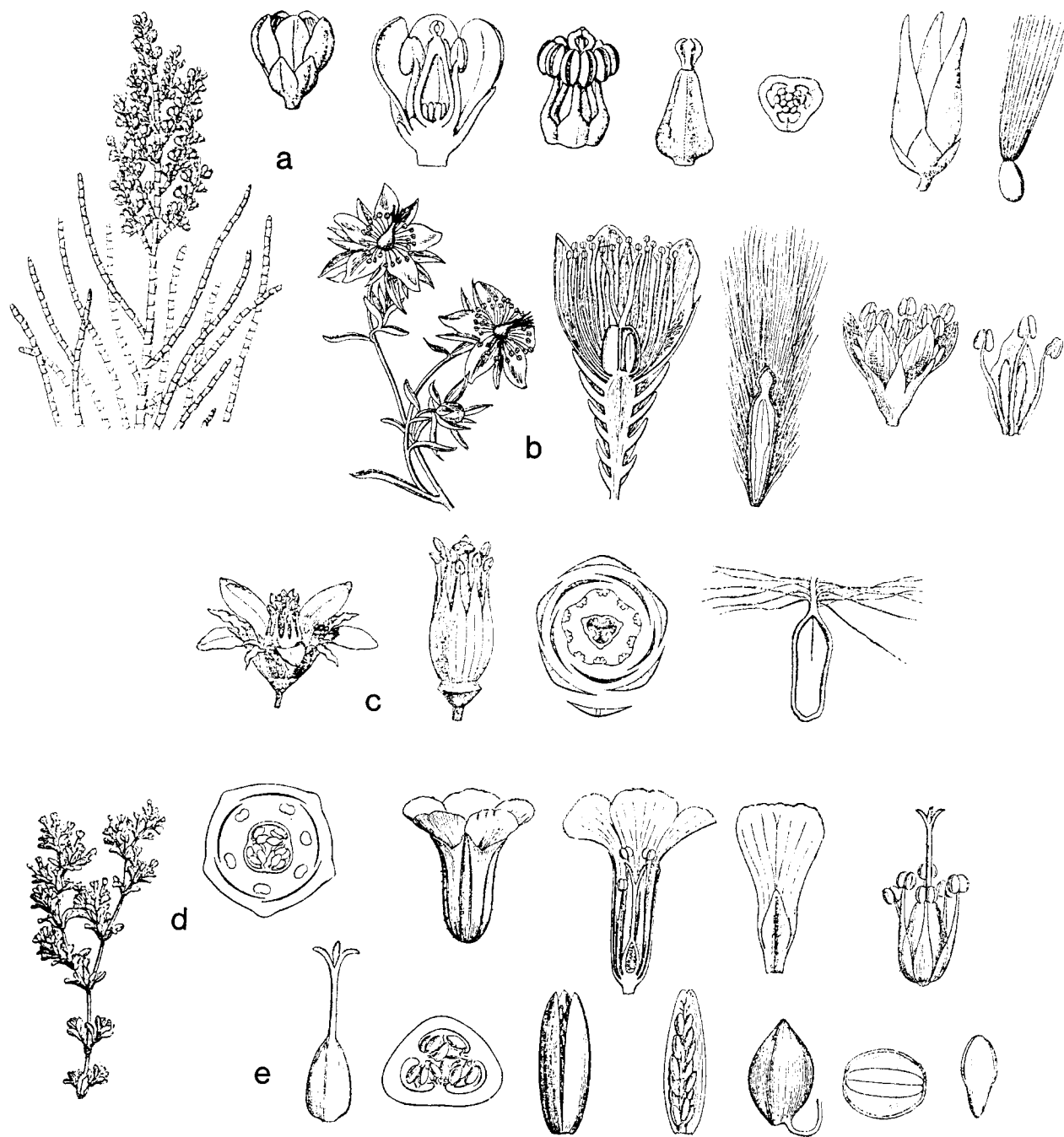


FIGURE 86.—TAMARICACEAE: *a*, *Tamarix articulata* flowering twig, flower, l.s. of same, essential organs, pistil, c.s. of ovary, dehiscent fruit, *T. senegalensis* seed; *b*, *Reaumuria hypericoides* flowering twig, l.s. of flower, l.s. of seed, *Hololachne songarica* flower, petal with ligule and stamens; *c*, *Myricaria germanica* flower, essential organs, floral diagram (after Marloth, 1925; Baillon, 1866–1895; Niedenzu). FRANKENIACEAE: *d*, *Frankenia pulverulenta* flowering shoot, floral diagram, flower, l.s. of same, petal, essential organs; *e*, pistil, c.s. of ovary, dehiscent fruit, valve of fruit with seeds, seed, c.s. of same, embryo (after Le Maout and Decaisne, 1873).

chasia, cincinni, sometimes scorpioid, or the flowers solitary; flowers bisexual or rarely the plants polygamo-monoecious, the parts hypogynous; sepals 4–6 (7), connate, the lobes short, induplicate-valvate; petals 4–6 (7), free or rarely connate (*Anthobryum*), with a ventral ligular process; stamens 4–6 (3–24), in 2 series, the filaments elongate, free or shortly connate; anthers small, about as long as wide, didymous, dorsifixed; pollen 3(2–4)-colpate or 6-rugate; pistil 1, the carpels 3 (2–4), the style 1, filiform, stigmas 3 (2–4), linear; ovary unilocular, the ovules 1–numerous per placenta, parietal, bitegmic, thinly crassinucellar, anatropous, the funicle sometimes long; fruit a loculicidal capsule; embryo straight, axile-peripheral, 1.1 times the length of the endosperm; cotyledons 1–1.8 times the width of the radicle, 0.3–0.6 the length of the embryo; endosperm copious or moderate, starchy.

Composition: 4 genera, ~70 species.

Distribution: Mainly saline habitats, centered in the Mediterranean region and southwestern Asia; southwestern United States to the western half of South America; northern and southern Africa; western and southeastern Australia; New Zealand.

MYRSINACEAE (Figure 87*a,b*).—Small trees and shrubs, rarely subherbs, rarely climbing, with resin canals, streaks, or dots in most of the tissues, including the flowers; xylem vessel perforation plates usually only simple, some scalariform plates in a few species; leaves alternate, sometimes subopposite or subverticillate, simple, entire or toothed, usually coriaceous, exstipulate; inflorescences axillary or terminal racemes, panicles, umbels, fascicles or cymes; flowers rather small, actinomorphic, bisexual or rarely the plants dioecious; sepals 5–4 (3–6, very rarely 9), free or basally connate; petals 5–4 (3–6, very rarely 7), connate or rarely free (*Embelia*), the corolla rotate or salverform, the tube short; stamens 5–4 (3–6), opposite the corolla lobes, the filaments short, adnate to the base of the corolla, rarely nearly free, sometimes shortly connate (*Aegiceras*), often nectariferous; anthers as long as wide or longer, rarely connate (*Amblyanthus*),

rarely transversely septate into locelli (*Aegiceras*, *Ardisia* sp.), dorsifixed or rarely basifixed, dehiscent longitudinally or by apical pores; pollen usually 3(2–5)-colpor(oid)ate, sometimes 4-rugate; pistil 1, the carpels 5–4 (3–6), the style 1, long, short or rarely absent, the stigma punctiform, capitate or 5–4(3–6)-lobed; ovary superior or rarely semi-inferior (*Maesa*), the ovules many to few, often embedded in the basal or free-central placenta, the integuments 2, rarely 1 (*Aegiceras*), tenuinucellar or rarely crassinucellar (*Aegiceras*), anatropous or amphitropous; fruit a berry or a drupe, or rarely longitudinally dehiscent by 1 slit (*Aegiceras*), the seeds 1 or several, small; embryo cylindrical, straight or arcuate, often transversely placed in the seed, 0.6–1.0 the length of the endosperm, the cotyledons 0.2–0.3 the length of the embryo, or rarely elongated and connate into a tube (*Aegiceras*), about as wide as the radicle; endosperm copious or 0 (*Aegiceras*), fleshy and oily or horny and semitransparent.

Composition: 35 genera, 1000 species.

Distribution: Warm temperate to tropical America and Africa; India to Japan and southeastern Asia, the East Indies, Australia, and New Zealand; one genus is a mangrove.

THEOPHRASTACEAE (Figure 87*c,d*).—Trees and shrubs without resin canals, streaks, or dots; xylem vessel perforation plates simple; leaves alternate, often subverticillate at the ends of the twigs or rarely opposite (*Jacquinia* sp.), simple, entire or toothed, exstipulate; inflorescences terminal or rarely axillary or cauliflorous, racemes, corymbs, fascicles, panicles, or rarely the flowers solitary, bracteolate; flowers bisexual or the plants dioecious, fairly large or small, actinomorphic; sepals 5 (4), free or shortly connate; petals 5 (4), connate, the tube usually short; stamens 5 (4), inserted on the base of the corolla opposite the lobes, the filaments free or basally connate (*Clavija*); staminodes 5 (4), sometimes fleshy-glandular or petaloid; anthers longer than wide, basifixed or slightly dorsifixed, the connective usually produced apically, dehiscent longitudinally; pollen 3-colporate, the colpi narrow;

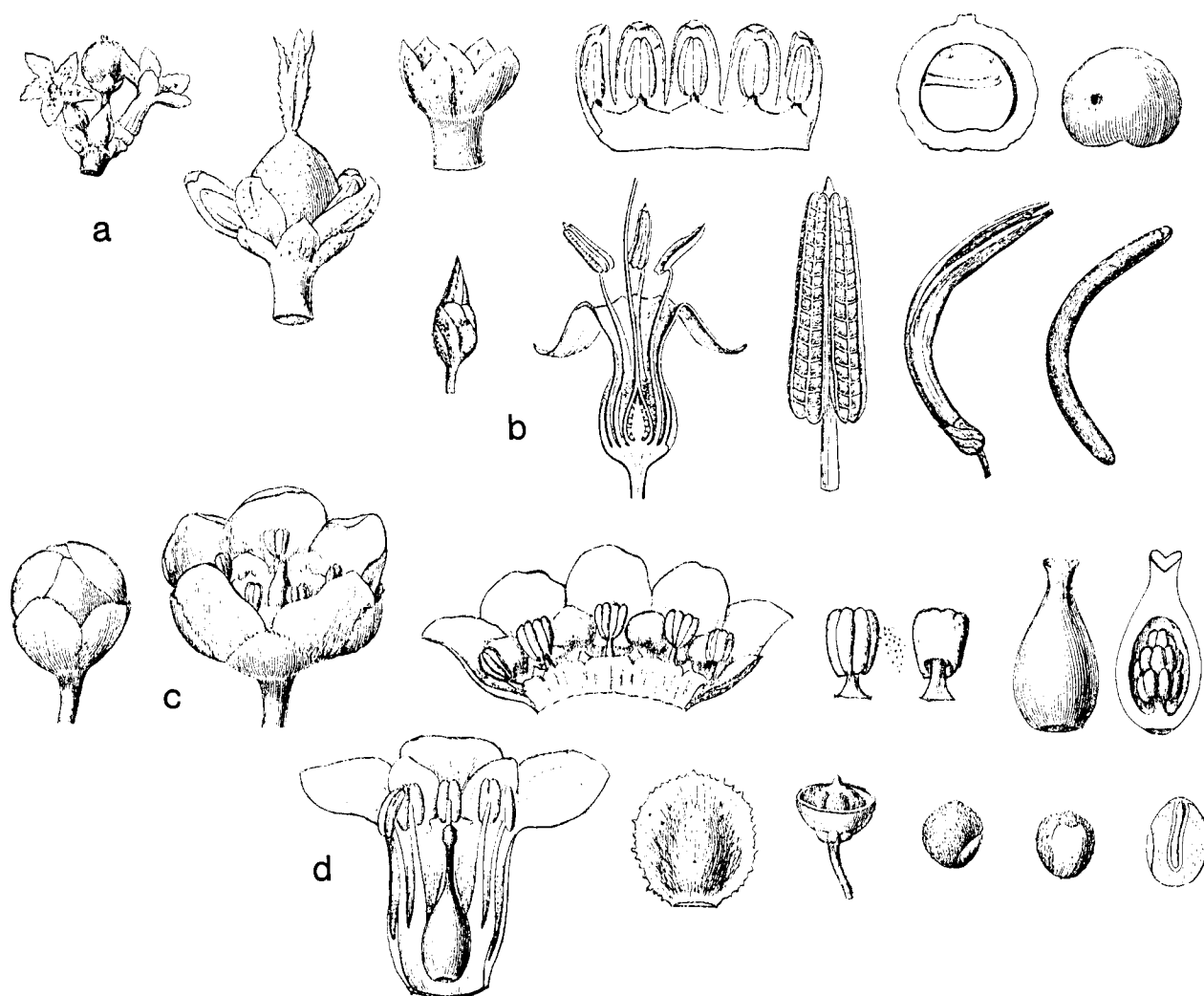


FIGURE 87.—MYRSINACEAE: *a*, *Rapanea umbellata* inflorescence, *R. leuconeura* flower, calyx, corolla laid open to show insertion of stamens opposite the petals, l.s. of fruit, seed; *b*, *Aegiceras corniculatum* bud, l.s. of flower, l.s. of anther, dehiscent fruit, seed (after Martius, 1840–1906; Baillon, 1866–1895; Mez). THEOPHRASTACEAE: *c*, *Clavija spinosa* bud, flower, corolla laid open to show insertion of stamens opposite the petals, and scales, views of stamen, pistil, l.s. of same; *d*, *Jacquinia aurantiaca* l.s. of flower, sepal, *J. armillaris* c.s. of fruit, views of seed, l.s. of seed (after Martius, 1840–1906).

pistil 1, the carpels 5, the style 1, or rarely nearly absent, the stigma discoid or rarely conical or irregularly lobed; ovary superior, unilocular, the ovules numerous or rarely few, bitegmic, tenuinucellar, anatropous, semi-anatropous, or subcampylotropous, the placenta basal or free-central, immersed in mucilage; fruit a berry or rarely a drupe or rarely almost dry, the seeds many to

1, often fairly large; embryo straight, 0.8 the length of the endosperm, the cotyledons 0.2–0.5 the length of the embryo, twice as wide as the radicle; endosperm copious, horny.

Composition: 5 genera, 110 species.

Distribution: Tropical to warm temperate America from Florida and the West Indies to Paraguay.

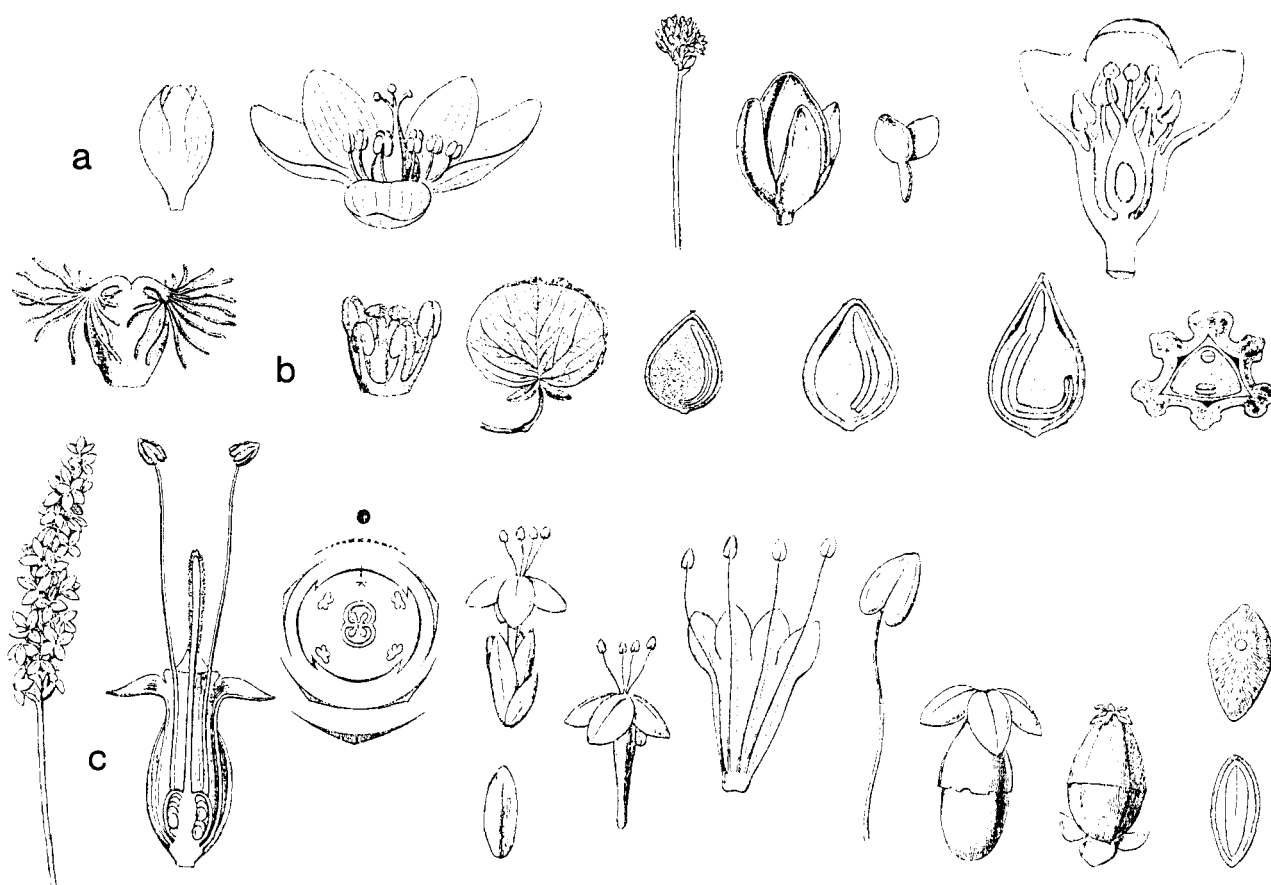


FIGURE 88.—POLYGONACEAE: *a*, *Polygonum meisnerianum* calyx, flower, *P. gilesii* inflorescence, fruit, embryo, *Coccoloba peltigera* l.s. of flower; *b*, *Oxyria digyna* pistil, *Atraphaxis spinosa* essential organs, fruit enclosed by the accrescent calyx, l.s. of fruit, *Rumex acetosella* l.s. of fruit, *Emex spinosa* l.s. and c.s. of fruit (after Hemsley; Martius 1840–1906; Dammer). PLANTAGINACEAE: *c*, *Plantago brasiliensis* inflorescence, *P. major* l.s. of flower, *P. brasiliensis* floral diagram, flower and sepal, corolla and stamens, corolla laid open, stamen, corolla and ovary, *P. major* fruit, seed and l.s. of same (after Martius, 1840–1906; Baillon, 1866–1895).

POLYGONALES

The order is monotypic.

POLYGONACEAE (Figure 88*a,b*).—Herbs, shrubs, small trees, and climbers, the stems mostly jointed and with swollen nodes; xylem vessel perforation plates simple; anomalous structure as medullary vascular bundles, intraxylar or interfascicular phloem in a few species; leaves alternate, rarely opposite or whorled, simple, mostly entire, mostly with a membranous stipule (ochrea) sheathing the stem at the base of the petiole; inflorescences terminal and axillary

cymes disposed in thyrses, racemes, spikes or heads; flowers bisexual or the plants polygamous, monoecious or dioecious, the parts hypogynous; sepals 3–6, free or connate, in 2 series when 4 or 6, often colored, often accrescent and membranous, rarely fleshy in fruit; petals 0; stamens usually 6–9, rarely less (1–5) or more (12–50), mostly in 2 series, the filaments filiform, free or shortly connate, sometimes adnate to the perianth; anthers about as long as wide, dorsifixed, wall development of the Monocot type; pollen 3–4-colporate, 4-ruporate, 6-rugorate, polyru-gate, polyforate, 8-colpate, 3-colporoidate; disk

annular, sometimes lobed, or central or glands at the base of the stamens; pistil 1, the carpels 3 (2–4), the styles 3 (2–4), usually free, stigmas enlarged, apical, or sometimes decurrent along the ventral surface of the style; ovary unilocular, the ovule basal, orthotropous, 2(1)-tegmic, crassinucellar, the funicle sometimes long; fruit a nutlet; embryo peripheral or axile, straight, arcuate, bent or folded, rarely convolute, 0.5–1.6 times the length of the endosperm; cotyledons moderately thick, or thin, 1–3 times the width of the radicle, 0.3–0.8 the length of the embryo; endosperm copious or moderate, hard and semitransparent, or occasionally crystalline-granular, farinaceous, rarely soft to firm and whitish.

Composition: ~40 genera, ~800 species.

Distribution: Dry or wet, often disturbed, habitats; cosmopolitan, centered in temperate Northern Hemisphere, few tropical or subtropical.

PLANTAGINALES

The order is monotypic.

PLANTAGINACEAE (Figure 88c).—Herbs and subshrubs; xylem vessel perforation plates simple; stem sometimes with cambial rows of cells in the cortex and/or pith, rarely forming medullary bundles; leaves radical, alternate or rarely opposite, simple, usually entire, exstipulate; inflorescences scapose spikes or heads or rarely the flowers solitary; flowers usually bisexual, sometimes also ♀ or the plants monoecious or gynodioecious; sepals 4, connate; petals 4 (3), scarious, connate, the lobes imbricate; stamens 4 (1–3), the filaments filiform, hypogynous or inserted on the corolla; anthers about as long as wide, dorsifixed; pollen with (3) 4–14 foramina, occasionally pori, sometimes slightly colpoid or rugoid; pistil 1, the carpels usually 2, the style 1, filiform; stigma decurrent all around the style for 0.3 its length or punctiform; ovary superior, 2(1–4)-locular, the ovules 1–40 per locule, unitegmic, tenuinucellar, semi-anatropous to anatropous, axile or basal; fruit a pyxis or nutlet; seeds usually pelately attached to the placentas; embryo straight

and axile or arcuate and peripheral (*Bougueria* and at least *Plantago lanceolata*), 0.9 the length of the endosperm; cotyledons 1–2 times the width of the radicle, 0.4–0.6 the length of the embryo; endosperm moderate or copious, firm, transparent and waxy in appearance.

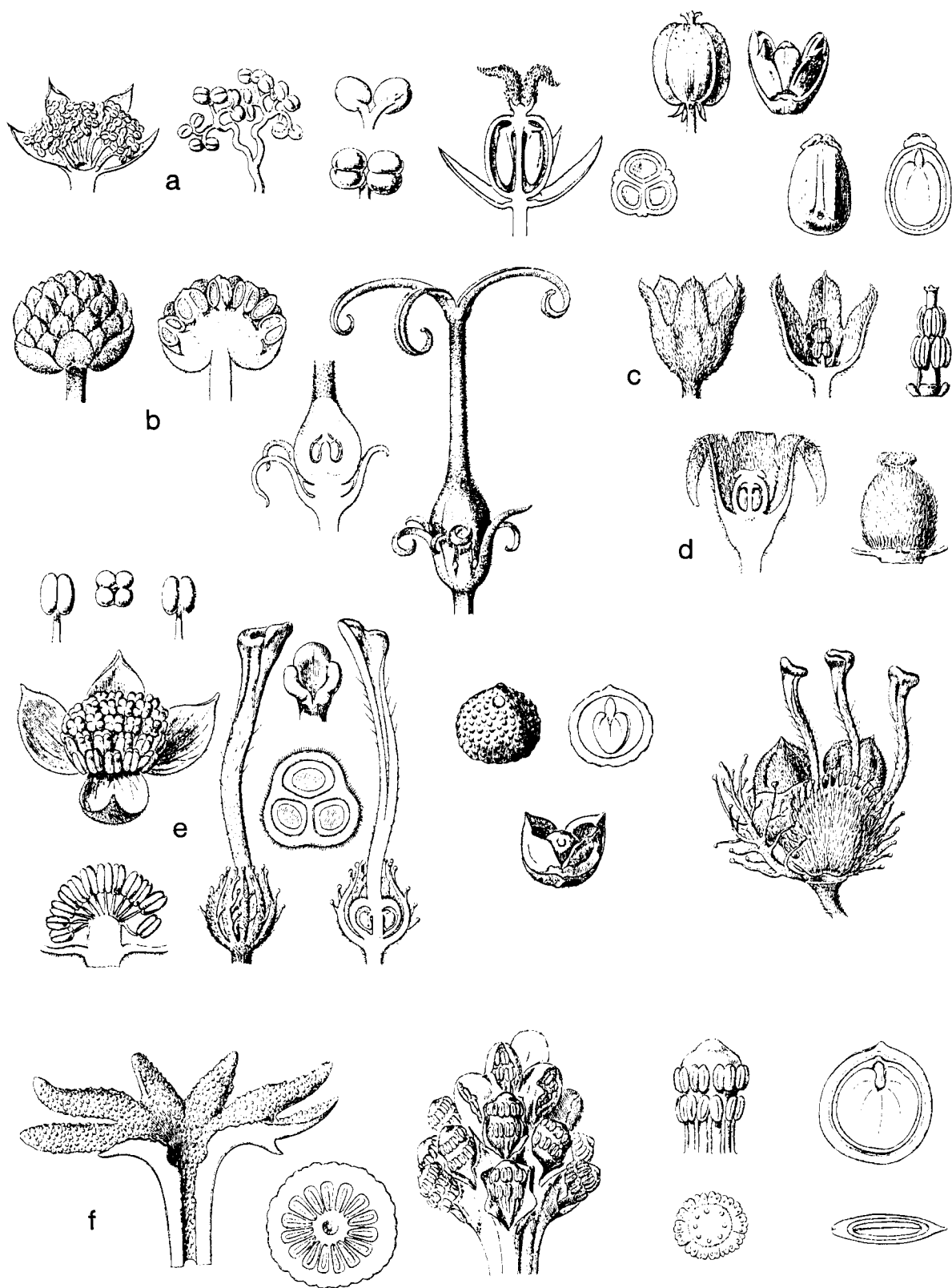
Composition: 3 genera, ~260 species.

Distribution: Various, often disturbed, habitats, few aquatic; pantemperate, especially in the Northern Hemisphere; in mountains in tropical regions.

EUPHORBIALES

Shrubs, trees, and herbs, sometimes laticiferous; xylem vessel perforation plates scalariform, simple or both; leaves alternate, rarely opposite, simple, entire or toothed, rarely lobed or palmately compound, extrafloral nectaries common, mostly stipulate; plants monoecious or dioecious; flowers anemophilous or entomophilous, the parts hypogynous, very rarely perigynous; sepals 5 (0, 2–6), free or connate; petals usually 0, sometimes 5 (4–12), free or rarely connate; stamens 5 or 10 (1 to ~300), the filaments free or connate in a column; anthers adnate, basifixed, more rarely dorsifixed, rarely connate; pollen 3 (2–10)-colpate, colpate, rugulate, forate or nonaperturate; glandular disk often present; pistil 1, the carpels 3 (1–20), styles usually free and bifid, the stigmas apical or decurrent ventrally; ovary superior 3 (1–20)-locular, the ovules 1–2 per locule, axile; fruit septicidal and ventricidal, forming cocci and leaving a columella, rarely a drupe or nut; seeds often carun-

FIGURE 89.—EUPHORBIACEAE: *a*, *Ricinus communis* l.s. of ♂ flower, stamen fascicle, views of anther, l.s. of ♀ flower, c.s. of ovary, fruit, dehiscent coccus, seed, l.s. of same; *b*, *Mabea fistuligera* ♂ flower, l.s. of same, l.s. of ♀ flower, ♀ flower; *c*, *Hevea discolor* ♂ flower, l.s. of same, staminal column; *d*, l.s. of ♀ flower, pistil; *e*, *Dalechampia stipulacea* views of anther, ♂ flower and l.s. of androecium, ♀ flower, stigma and c.s. of ovary, l.s. of ♀ flower, seed, l.s. of same, dehiscent coccus (below), inflorescence; *f*, *Hura crepitans* stigmas, c.s. of ovary, ♂ inflorescence, staminal column and c.s. of same, l.s. and c.s. of seed (after Martius, 1840–1906).



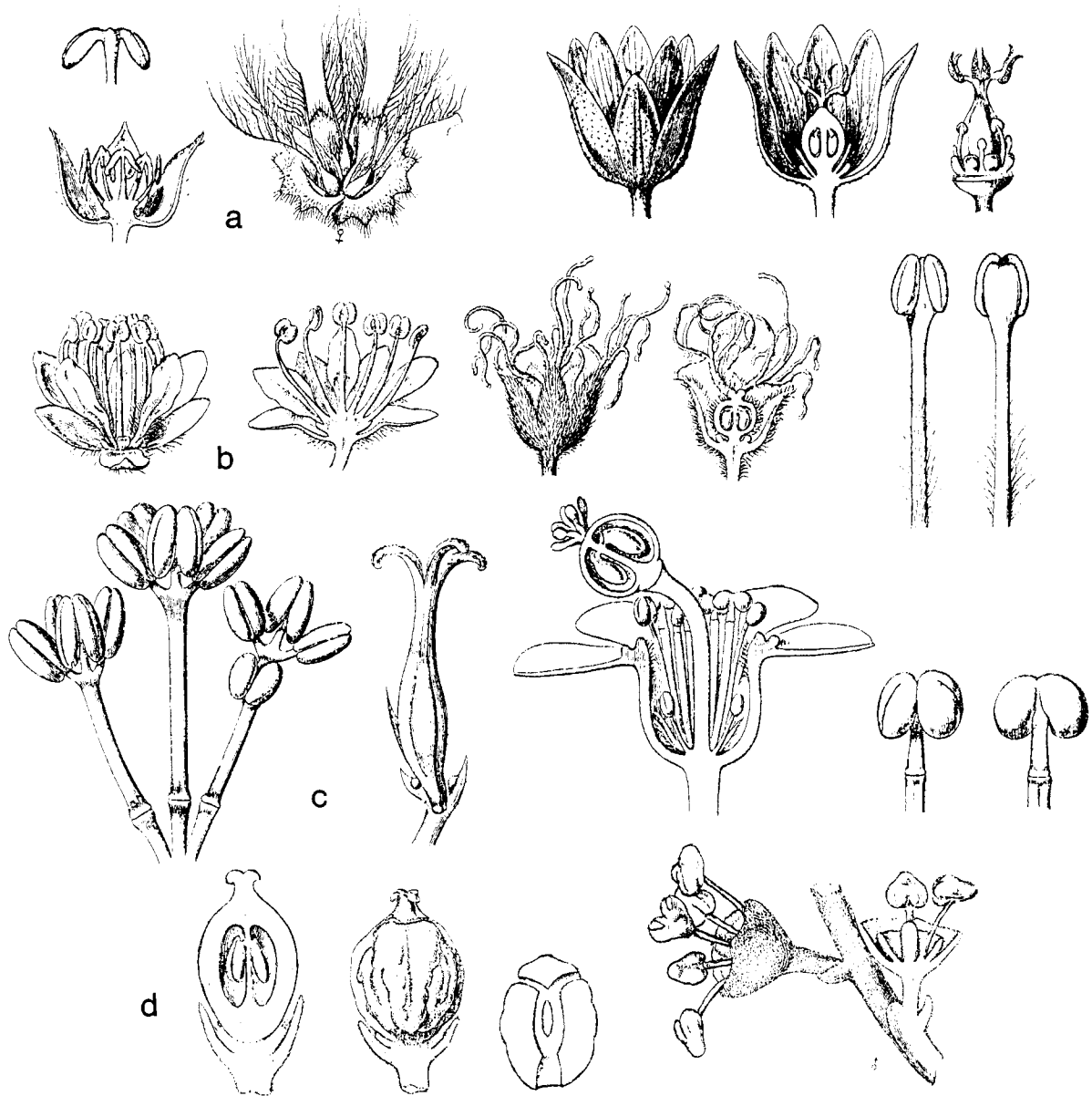


FIGURE 90.—EUPHORBIACEAE: *a*, *Acalypha amblyodonta* stamen before dehiscence and l.s. of ♂ flower, 3 ♀ flowers subtended by a bract, *Jatropha curcas* ♀ flower, l.s. of same, pistil, staminodes and glands; *b*, *Croton comosus* ♂ flower, l.s. of same, ♀ flower, l.s. of same, *C. migrans* views of stamen; *c*, *Actinostemon concolor* 3 ♂ flowers, ♀ flower, *Euphorbia coecorum* l.s. of inflorescence, views of ♂ flower; *d*, *Hieronymia alchorneoides* l.s. of pistil, fruit, section of putamen, ♂ flower and l.s. of same (after Martius, 1840–1906).

culate, the embryo varied; endosperm copious or moderate, rarely scanty or absent.

Distribution: Cosmopolitan, predominantly tropical to warm temperate.

Chemistry: Euphorbiales produce many alka-

loids, e.g., aporphine, pyridine, indole, quinoline, and tropine. Mustard oil glycosides occur in *Putranjiva* (= *Drypetes*).

EUPHORBIACEAE (Figure 89a–f, Figure 90a–d).—Shrubs, trees, and herbs, sometimes

laticiferous; xylem vessel perforation plates scalariform, simple or both; leaves alternate or rarely opposite or whorled, simple or sometimes palmately compound, the margin entire or serrate, mostly stipulate; extra-floral nectaries are common; inflorescences axillary spike, raceme, thyrses, cymes, or solitary, occasionally cauliflorous; the plants mostly monoecious, sometimes dioecious; flowers anemophilous or entomophilous, the parts hypogynous, very rarely perigynous (*Bridelia*); sepals 5 or 0 (2–6); petals usually absent, sometimes 5 (8–12 in *Garcia*), free or rarely connate; stamens usually 5 or 10 (1–300?), the filaments free or connate in a column, sometimes branched with several hundred anthers (*Ricinus*); anthers adnate, basifixed or more rarely dorsifixed, rarely connate, sometimes the thecae are separate; pollen 3(2–10)-colpate, colporate, rugorate, forate, foraminoidate, or non-aperturate; disk often present in both sexes, annular or of separate glands; pistil 1, the carpels usually 3 (1–20); the styles free, usually bifid, sometimes united, the stigmas apical or decurrent ventrally; ovary 3(1–20)-locular, the ovules 1–2 per locule, axile, 2(1)-tegmic, crassinucellar, anatropous, rarely orthotropous; fruit usually septicidal, dehiscent into 2-valved cocci open ventrally, and leaving a columella, sometimes a drupe; seeds often carunculate, rarely lobed (*Picrodendron*); embryo spatulate or rarely linear and terete, straight or rarely arcuate or folded, 0.7–1.0 the length of the endosperm; cotyledons very thin to moderately thick, 1–5.3 (–7.0) times the width of the radicle, 0.5–0.9 the length of the embryo; endosperm copious or moderate, rarely scanty or 0, fleshy.

Composition: ~300 genera, ~6000 species.

Distribution: Cosmopolitan except for the arctic and cool temperate regions of the Northern Hemisphere; predominantly tropical to warm temperate.

AEXTOXICACEAE (Figure 91a).—Trees; xylem vessel perforation plates scalariform with many bars; leaves alternate or subopposite, simple, entire, the underside covered with scales, exstipulate; plants dioecious; inflorescences axillary racemes; flower parts hypogynous; sepals 5 (4–6),

free, imbricate; petals 5 (4–6); stamens 5, free, alternating with large reniform disk-glands, the filaments thick; anthers about as long as wide; pollen 3-colpate; pistil 1, the carpels 2, the style 1, shortly bifid apically; ovary unilocular, the ovules 2, subapical, bitegmic, crassinucellar, anatropous; fruit a drupe or nut; embryo 0.5 the length of the endosperm; cotyledons ovate or orbicular, cordate, 4 times wider than the radicle, 0.6 the length of the embryo; endosperm copious, ruminant, fleshy.

Composition: 1 genus, 1 species.

Distribution: Chile.

PANDACEAE (Figure 91b,c).—Trees; xylem vessel perforation plates simple and scalariform, with 6–10 (to 20 if *Galearia* is included) bars; leaves alternate, simple, distichous, toothed, stipulate; inflorescences elongated, cauliflorous in clusters of racemes (♀), sometimes several flowers per inflorescence node (♂), the plants dioecious; flowers actinomorphic; sepals 5, connate nearly to the apex; petals 5, free, imbricate to subvalvate; stamens free, 10 in 2 series of 2 lengths (5–15 if *Galearia* and *Microdesmis* are included), the filaments shorter than the petals, the anthers bilocular, about as long as wide, dehiscent longitudinally; pollen 3-colpate; disk small, intrastaminal; pistil 1, the carpels (2–) 3–4, the styles (stigmas) (2–) 3–4, 1 mm long, 1 mm wide; ovary superior, (2–) 3–4-locular, the ovules 1 per locule, bitegmic, orthotropous in *Panda*, obturator 0, axile-apical; fruit a large drupe, the endocarp hard, thick, sculptured, containing 3 one-seeded chambers, dehiscent by valves at germination, the embryo 0.9 the length of the endosperm, the cotyledons flattened, thin, curved, truncate apically, cordate basally, 0.9 the length of the embryo, 7 times wider than the radicle, the latter slightly invested; endosperm copious, oily.

Composition: 4 genera, 28 species.

Distribution: Tropical western Africa, south-eastern Asia, Malaysia.

MALVALES

Trees, shrubs, and herbs, often with mucilage cells or canals and stellate hairs; xylem vessel

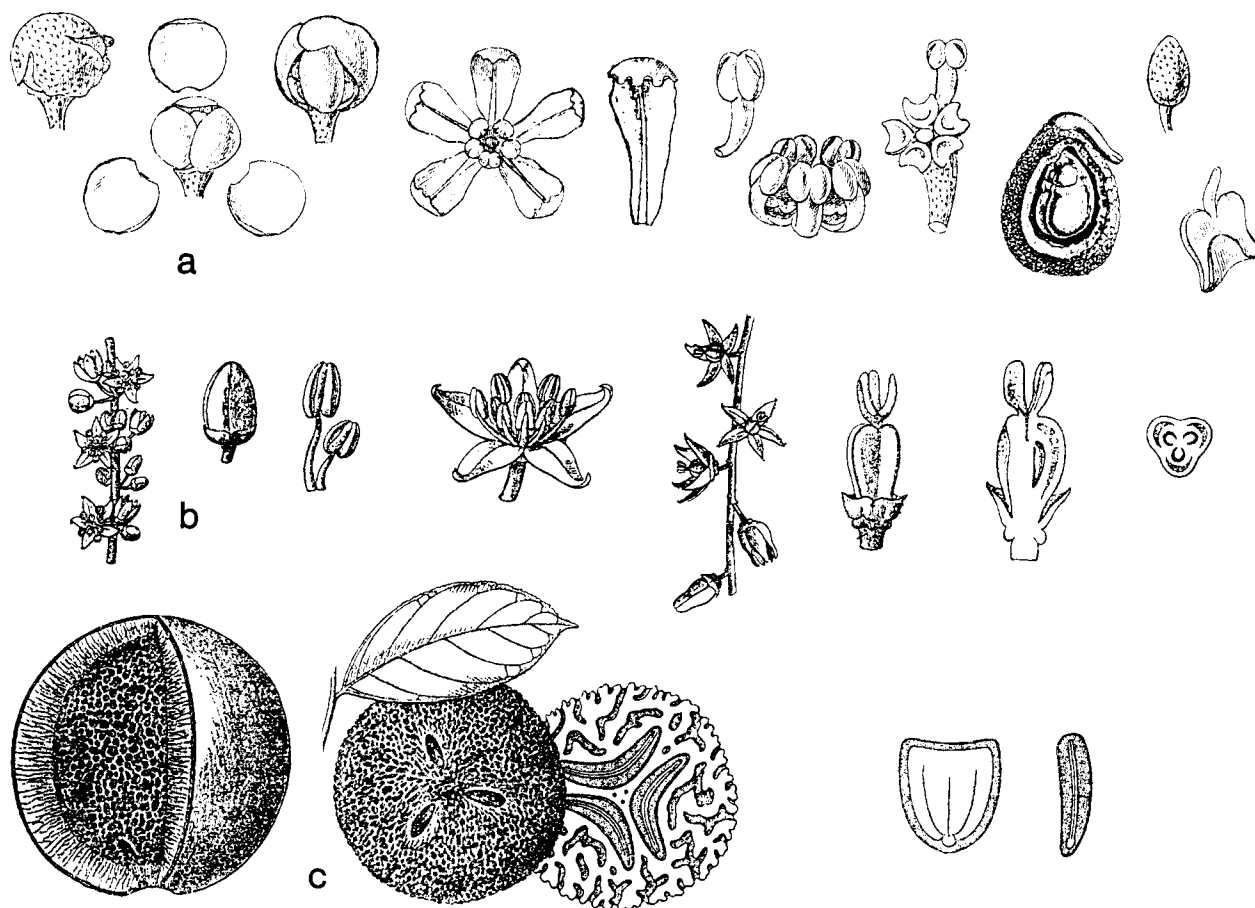


FIGURE 91.—AEXTOXICACEAE: *a*, *Aextoxicon punctatum* calyx (bract ?) of ♂ flower bursting irregularly, ♂ bud with 3 outer sepals removed and 3 inner attached, bud from which the calyx has been removed showing the unexpanded petals, open flower from which the calyx has fallen, petal, stamen, androecium, 1 stamen and 5 nectaries surrounding the pistillode, pistil opened to show the ovules, fruit, embryo (after Baillon, 1866–1895; Hooker and Hooker, 1837–1982). PANDACEAE: *b*, *Panda oleosa* part of ♂ inflorescence, bud, an outer and an inner stamen, ♂ flower, part of ♀ inflorescence, calyx and pistil of ♀ flower, l.s. and c.s. of ovary; *c*, fruit with part of the exocarp removed, putamen from beneath and leaf, c.s. of putamen showing the 3 seeds, l.s. of seed, radial l.s. of seed (after Engler).

perforation plates simple, rarely also a few scariform; bast fibers often tough; leaves alternate or more rarely opposite, simple, rarely digitately compound, entire or toothed, stipulate; flowers mostly bisexual, the parts hypogynous; sepals 5 (3, 4), usually connate and valvate, an epicalyx sometimes present; petals 5 (0, 3, 4), free or rarely connate; stamens usually numerous, to ~80, rarely 4, 5, or 10, often connate in a tube closely surrounding the pistil and adnate to the

base of the petals, rarely free or in a column or bundles; staminodes sometimes present; anthers rarely in bundles, dorsifixed, 2(1)-locular, longitudinally dehiscent, rarely poricidal; pollen 3(–8)-colporate, 3-colpate, 3–9-porate or forate, 4-ruporate or 6-rugorate; glandular disk sometimes surrounding the base of the ovary; pistils 1–5 (–65), the carpels 5 (1 to ~20), styles 1 to as many, rarely twice as many, as carpels, free or connate, the stigmas apical or decurrent ven-

trally, rarely sessile; ovary superior 5(1 to ~20)-locular, the ovules 1-many per locule, axile, very rarely parietal; fruit a loculicidal, septicidal, and sometimes ventricidal capsule, schizocarp, drupe, berry, samara or nut; seeds sometimes winged, covered with long hair or arillate; embryo large, straight, curved, or folded; endosperm copious to absent.

Distribution: Cosmopolitan, especially pantropical, relatively few in temperate regions and absent from the arctic, in various habitats.

Chemistry: Cyclopropenyl fatty acids are known from Tiliaceae, Malvaceae, Bombacaceae, and Sterculiaceae. They have not been reported outside the order. Gibbs says chemically Scytopetalaceae may not belong in the order.

STERCULIACEAE (Figure 92a-e).—Trees and shrubs, rarely herbs or lianas; indument predominantly stellate, but other types also common; plants with mucilaginous receptacles; xylem vessel perforation plates simple; bast fibers tough; leaves alternate, rarely opposite (*Lasiopetalum* spp.), simple or digitately compound, entire, serrate or crenate, stipulate; inflorescences axillary and leaf-opposed, rarely terminal, sometimes cauliflorous, cymes and panicles, rarely the flowers solitary (*Octolobus*); flowers bisexual or the plants monoecious, the parts hypogynous (stamens slightly perigynous in some *Thomasia*); sepals 5 (3, 4), connate (free in *Lysiosepalum*), valvate; petals 5 or 0, free or adnate basally to the staminal tube, contorted; stamens 5 or 10 (~4–45), connate into a tube in bisexual flowers and column in ♂ flowers, rarely free, often alternate with showy staminodes; anthers sometimes in bundles, bilocular, dorsifixed, longitudinally dehiscent, rarely poricidal; pollen 3–9-porate or forate, 3(–8)-colporate, or 3-colpate; pistils 1–5 (–65 in *Octolobus*), carpels 5 (1–12), the styles free to united most of the way; ovary 5(1–12)-locular, the ovules 2 or more per locule, axile, bitegmic, crassinucellar, anatropous; fruit a follicular capsule, sometimes spiny, schizocarp or samara, rarely baccate; seeds sometimes winged or covered with long hairs; embryo straight, curved or folded, 0.9 the length of the endo-

sperm; cotyledons thin or thick, to 4.4 times wider than the radicle, 0.5–0.8 the length of the embryo, the radicle sometimes invested; endosperm copious, moderate or 0, fleshy.

Composition: ~65 genera, ~800 species.

Distribution: Pantropical, extending into subtropical regions, very few temperate.

ELAEOCARPACEAE (Figure 92f,g).—Trees and shrubs with mucilage cells but cavities and canals absent; xylem vessel perforation plates simple, sometimes also a few scalariform; leaves alternate or opposite, simple, toothed or entire, stipulate; inflorescences racemes, panicles or dichasia; flowers bisexual or rarely unisexual, the parts hypogynous, rarely subperigynous; sepals 4–5, free or connate, valvate or imbricate; petals 4–5 or 0, rarely connate, often apically fimbriate, valvate or imbricate, not contorted; stamens numerous (~25–80), free, the filaments elongate; anthers dorsifixed, bilocular, usually dehiscent by 2 pores or short slits, rarely by a transverse valve or at the base; pollen 3-colporate; disk usually surrounding the base of the ovary; pistil 1, the carpels 2–5 (–7), the style 1 (0), punctate or shortly lobed, the stigmas apical, rarely sessile; ovary 2–5(1–7)-locular, the ovules 2–several per locule, axile, rarely subapical, bitegmic, crassinucellar, anatropous; fruit a septicidal or loculicidal capsule, sometimes densely echinate, or drupe or berry; embryo straight, 0.75–0.9 the length of the endosperm; cotyledons thin, 4 times wider than the radicle, 0.5–0.9 the length of the embryo; endosperm copious.

Composition: 12 genera, ~350 species.

Distribution: Mainly tropical and subtropical; subtropical China to the East Indies, eastern Australia, New Zealand; Japan; West Indies; southern South America; absent from Africa.

TILIACEAE (Figure 93a,b).—Trees and shrubs, rarely herbs, often with stellate indument, but other types also present; plants with mucilage cells, cavities or more rarely canals; xylem vessel perforation plates simple; bast fibers tough; leaves alternate, rarely opposite, simple, usually serrate, stipulate; inflorescences axillary, rarely leaf-opposed, cymose; flowers bisexual or rarely

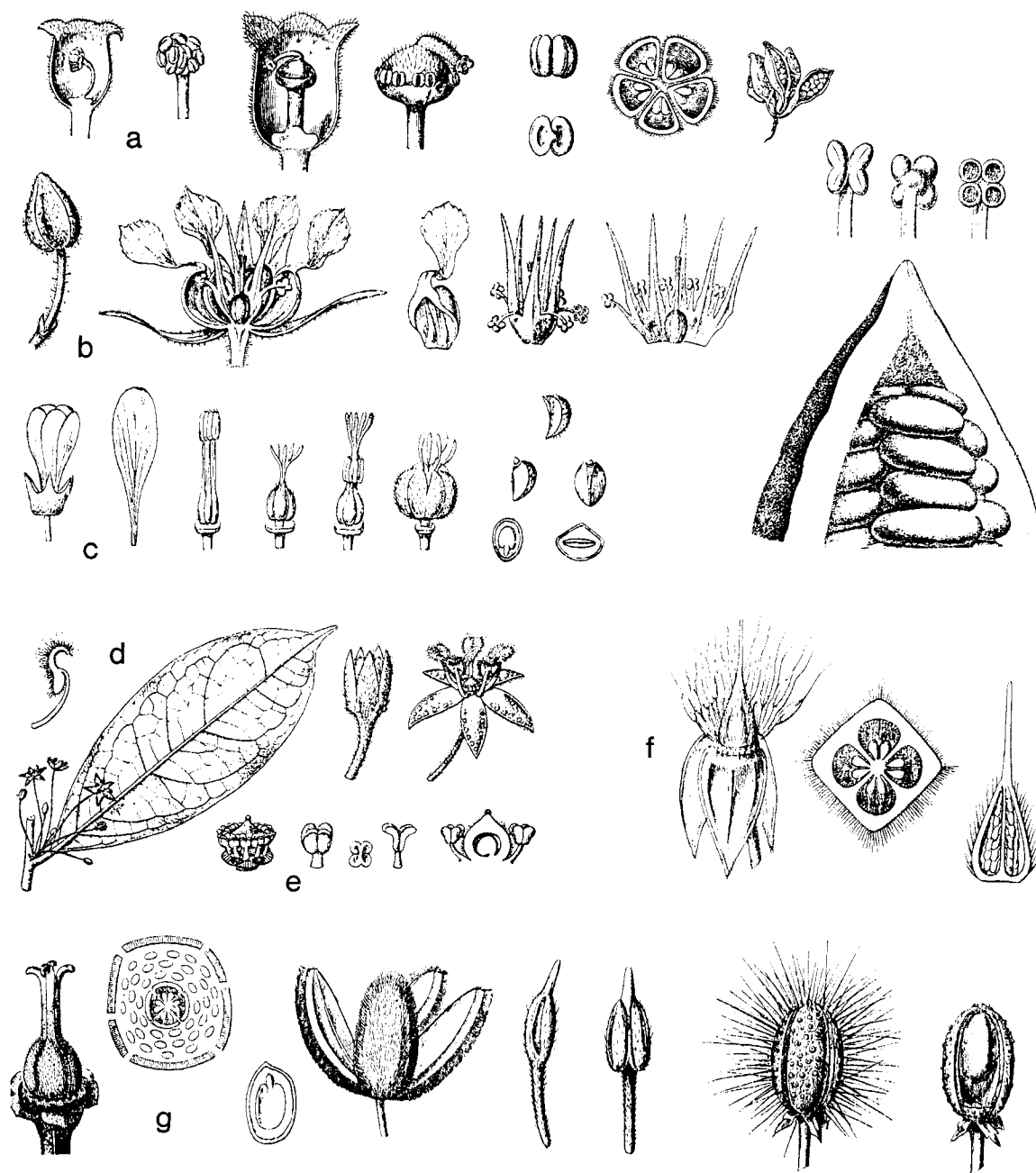


FIGURE 92.—STERCULIACEAE: *a*, *Sterculia striata* l.s. of ♂ flower, staminal column, l.s. of ♀ flower, pistil and stamens, views of anther, c.s. of ovary, *Brachychiton populneum* dehiscent fruit (reduced); *b*, *Theobroma cacao* bud, l.s. of flower, petal, flower with perianth removed, staminal-staminodal tube laid open, views of anther and part of fruit opened to show the seeds; *c*, *Melochia simplex* flower, petal, staminal tube from brevistylous flower, pistil, essential organs from longistylous flower, fruit, coccus, views of seed, c.s. of same, *M. graminifolia* l.s. of seed; *d*, *Hua parvifolia* staminode (petal ?), part of flowering twig, bud, flower; *e*, essential organs, views of stamen, stamens and l.s. of pistil (after Martius, 1840–1906; Johnson; Lindley, 1853; Engler and Krause). ELAEOCARPACEAE: *f*, *Sloanea garckeana* flower, c.s. and l.s. of ovary; *g*, *S. eichleri* pistil, floral diagram, l.s. of seed, *S. garckeana* dehiscent fruit, *S. alnifolia* views of stamen, fruit, same opened to show seed (after Martius, 1840–1906).

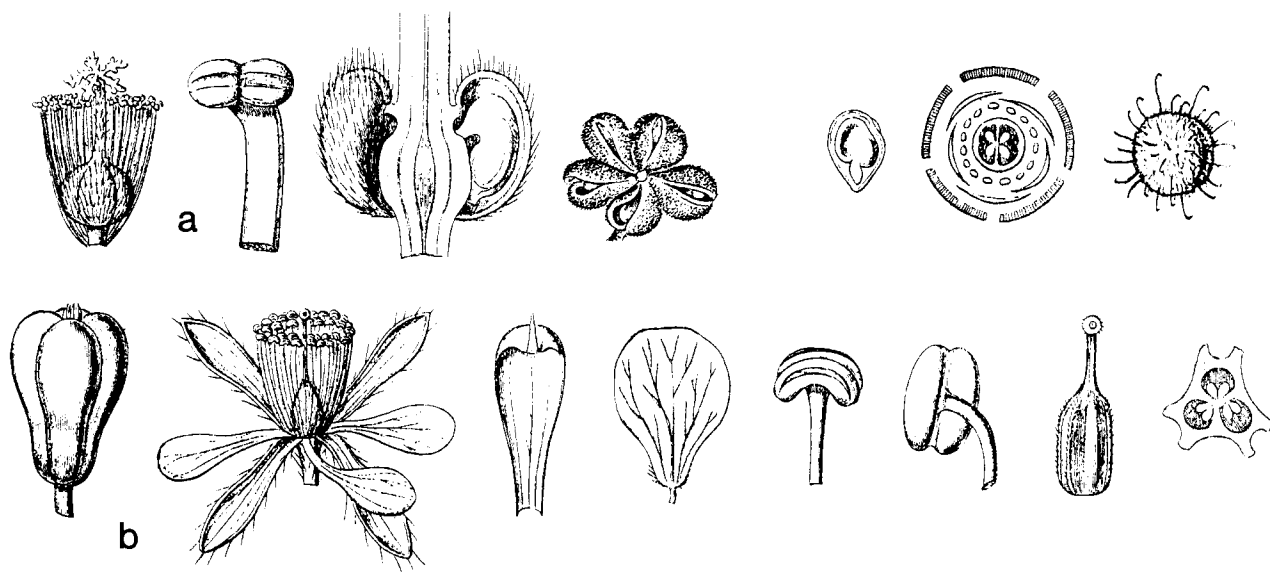


FIGURE 93.—TILIACEAE: *a*, *Christiana africana* pistil and staminodes, stamen, l.s. of ovary, dehiscent fruit, *Triumfetta semitriloba* l.s. of seed, *T. rhomboidea* floral diagram, fruit; *b*, *Corchorus acutangulus* bud, *C. hirtus* flower, *C. acutangulus* sepal, petal, *C. hirtus* views of anther, *C. acutangulus* pistil, c.s. of ovary (after Martius, 1840–1906).

the plants monoecious or dioecious (*Heliocarpus*), the parts usually hypogynous; sepals 5 (3–4), free or basally connate, valvate, an epicalyx sometimes present; nectariferous tissue at base of sepals or petals; petals 5 (3, 4, 0), free, contorted; stamens usually numerous (~5–85), free or shortly connate, or in 5–10 bundles, the filaments elongate; anthers bilocular, about as long as wide, dorsifixed, dehiscing by longitudinal slits or rarely by apical pores; pollen usually 3(–4)-colporate, more rarely 4-ruporate, 6-rugorate, or oligoforate; pistil 1, the carpels 2–10, rarely nearly apocarpous (*Glabraria*, *Christiana*), the style usually 1, apex divided or not, the stigma(s) capitate or lobed, rarely sessile; ovary superior, rarely inferior (*Neotessmannia*, *Dicraspidia*), 2–10-locular, the septa rarely incomplete in the upper part of the ovary, the ovules 2 (1–several) per locule, axile, very rarely parietal, bitegmic, crassinucellar, anatropous or semi-anatropous; fruit a loculicidal, sometimes echinate capsule, schizocarp, nut or samara, rarely subbaccate; embryo straight, arcuate or folded, 0.9–1.7 times the length of the endosperm; cotyledons thin, 8

times wider than the radicle, 0.5 the length of the embryo; endosperm usually copious, rarely 0, fleshy.

Composition: 50 genera, 450 species.

Distribution: Pantropical, especially South America and southeastern Asia; few temperate.

MALVACEAE (Figure 94*a,b*).—Herbs and shrubs, rarely trees, the indument usually stellate; plants with mucilage cells; xylem vessel perforation plates simple; bast fibers tough; leaves alternate, simple, serrate or crenate, sometimes palmately lobed, stipulate; inflorescences cymose, in cincinni, or the flowers solitary; flowers bisexual, or the plants rarely polygamous or dioecious (*Napaea*), the parts hypogynous; sepals 5 (–3), connate, valvate, an epicalyx often present; petals 5, contorted or imbricate, usually asymmetrical, free from one another but usually adnate to the base of the staminal column; stamens numerous (to ~60), very rarely 5 or 10, the filaments connate in a tube closely surrounding the pistil; anthers unilocular, dorsifixed, dehiscing longitudinally; pollen large, spiny, 3–4-colporate, polyrugorate or (oligo-) polyforate;

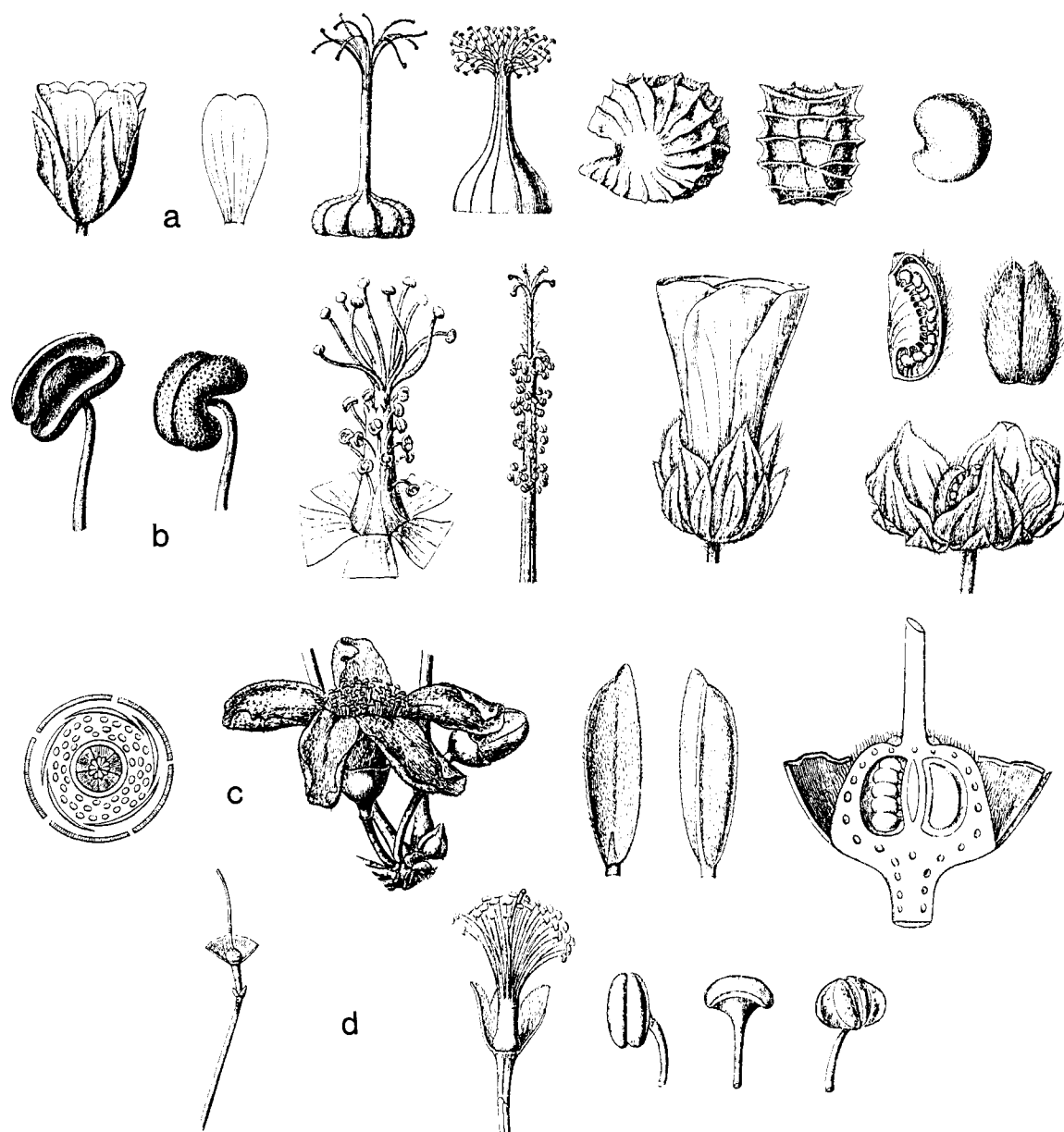


FIGURE 94.—MALVACEAE: *a*, *Malva parviflora* flower, petal, pistil, androecium, views of mericarp, seed; *b*, *Abutilon megapotamicum* views of anther, *Pavonia flavispina* staminal tube and style branches, *Hibiscus peterianus* staminal tube and style branches, *H. spathulatus* flower, 2 views of fruit valve and dehiscent fruit subtended by calyx and epicalyx (after Martius, 1840–1906). BOMBACACEAE: *c*, *Bombax gracilipes* floral diagram, flower and bud, views of petal, l.s. of ovary (enlarged); *d*, pistil, *B. wittrockianum* staminal tube and style, views of anther (after Martius, 1840–1906).

pistil 1, the carpels 5 (1 to ~20), the styles usually free for a considerable distance, sometimes connate nearly to the apex, sometimes twice as many as the ovary locules, the stigmas apical or decur-

rent on the ventral surface of the style (*Malva*, *Kitaibelia*); ovary 5(1 to ~20)-locular, the ovules 1–many per locule, axile, bitegmic, crassinucellar, anatropous or campylotropous; fruit a schiz-

ocarp or loculicidal capsule, rarely a berry (*Malvaviscus*); embryo folded or rarely arcuate (*Malachra*), 1.6–1.8 times longer than the endosperm; cotyledons 4–5 times wider than the radicle, 0.5–0.8 the length of the embryo; endosperm scanty or 0, fleshy or hard, sometimes oily.

Composition: ~80 genera, ~1300 species.

Distribution: Cosmopolitan, but absent from arctic Northern Hemisphere; centered in tropical South America.

BOMBACACEAE (Figure 94*c,d*).—Trees, the indument stellate or lepidote; plants with mucilage cells and cavities; xylem vessel perforation plates simple; bast fibers tough; leaves alternate, simple or digitately compound, the margins entire or rarely toothed (*Chorisia*), stipulate; inflorescences axillary or terminal cymes, or the flowers solitary; flowers bisexual, the parts hypogynous, very rarely perigynous (*Coelostegia*); sepals 5, connate, valvate (slightly imbricate in *Ochroma*), an epicalyx sometimes present; petals 5 (0 in *Cullenia*), convolute, asymmetric; stamens often numerous, 5 to ~100, free or connate into a tube closely surrounding the pistil, staminodes sometimes present; anthers 1–2 or more locular, dorsifixed, dehiscing longitudinally; pollen usually smooth, 3-porate, 3-colporate, 4-colpate; pistil 1, the carpels 2–5, the style 1, the apex lobed or capitate; ovary 2–5-locular, the ovules 2—many per locule, axile, bitegmic, crassinucellar, anatropous; fruit a loculicidal capsule or indehiscent and the seeds with a large aril, or a samara; embryo contorted or plicate, 1.7 times longer than the endosperm; cotyledons flat, thick, 0.5 the length of the embryo; endosperm scanty, fleshy.

Composition: ~25 genera, ~200 species.

Distribution: Pantropical, especially rain forest of South America, but also in dry habitats.

ROSALES

Shrubs, herbs, and trees, xylem vessel perforation plates simple, rarely also scalariform; leaves alternate, rarely opposite, simple or compound, usually toothed, sometimes dissected, lobed or entire, mostly stipulate; flowers bisex-

ual, rarely unisexual, the parts hypogynous, perigynous or epigynous, an hypanthium sometimes present; sepals 5 (3–10), free or basally connate, an epicalyx sometimes present; petals 5 (3–10, 0), free or sometimes inserted on the calyx; stamens usually numerous in 1–4 or more series, to ~400, rarely 1–5; staminodes very rarely present; filaments free, very rarely connate, very rarely inserted on the base of the petals, the anthers dorsifixed; pollen 3(2–4)-colporate, rarely 3(4)-pororate or unique; glandular tissue usually lines the receptacle between the stamens and the pistils; pistils numerous, to ~150, to 1, sometimes spirally arranged, the carpels 5 (2–15) in the compound pistils, styles free or rarely connate, the stigmas apical, very rarely decurrent ventrally; ovary superior to inferior, 5(2–15)-locular, the ovules 2 (1–24) per locule, axile, very rarely apical; fruit follicles, achenes, drupe(s), pome, rarely a capsule, the seeds very rarely arillate; embryo large, spatulate or linear, straight, bent, arcuate or folded; endosperm mostly scanty or absent, rarely moderate.

Distribution: Cosmopolitan, centered in temperate and subtropical Northern Hemisphere, mostly in open habitats.

Chemistry: In contrast to Fabales, alkaloids and coumarins are remarkably rare in Rosaceae. Rosales and Theales, at least the primitive members, contain trihydroxylated phenolic substances such as ellagic acid, gallic acid, myricetin, and leucodelphenidin. These are absent from the "Polycarpicae." Some alkaloids highly characteristic of "Polycarpicae," e.g., protoaporphines, aporphines, berberin, and other quaternary bases, are absent from the Rosales and Theales. Ellagic acid occurs in Rosoideae and Myrtales and elsewhere. Rosaceae and Myrtaceae sometimes have the same alcohols; p-coumaroyl-quinic acid occurs in *Malus* and *Eucalyptus*. Nitrogen fixing plants include some Casuarinaceae, Myricaceae, Betulaceae, Rosaceae, Coriariaceae, Rhamnaceae, and Elaeagnaceae. The Crossosomataceae seem to be characterized by possession of syringin, which also occurs in Magnoliaceae. The Rosaceae and Fabales are highly cyanogenic groups.

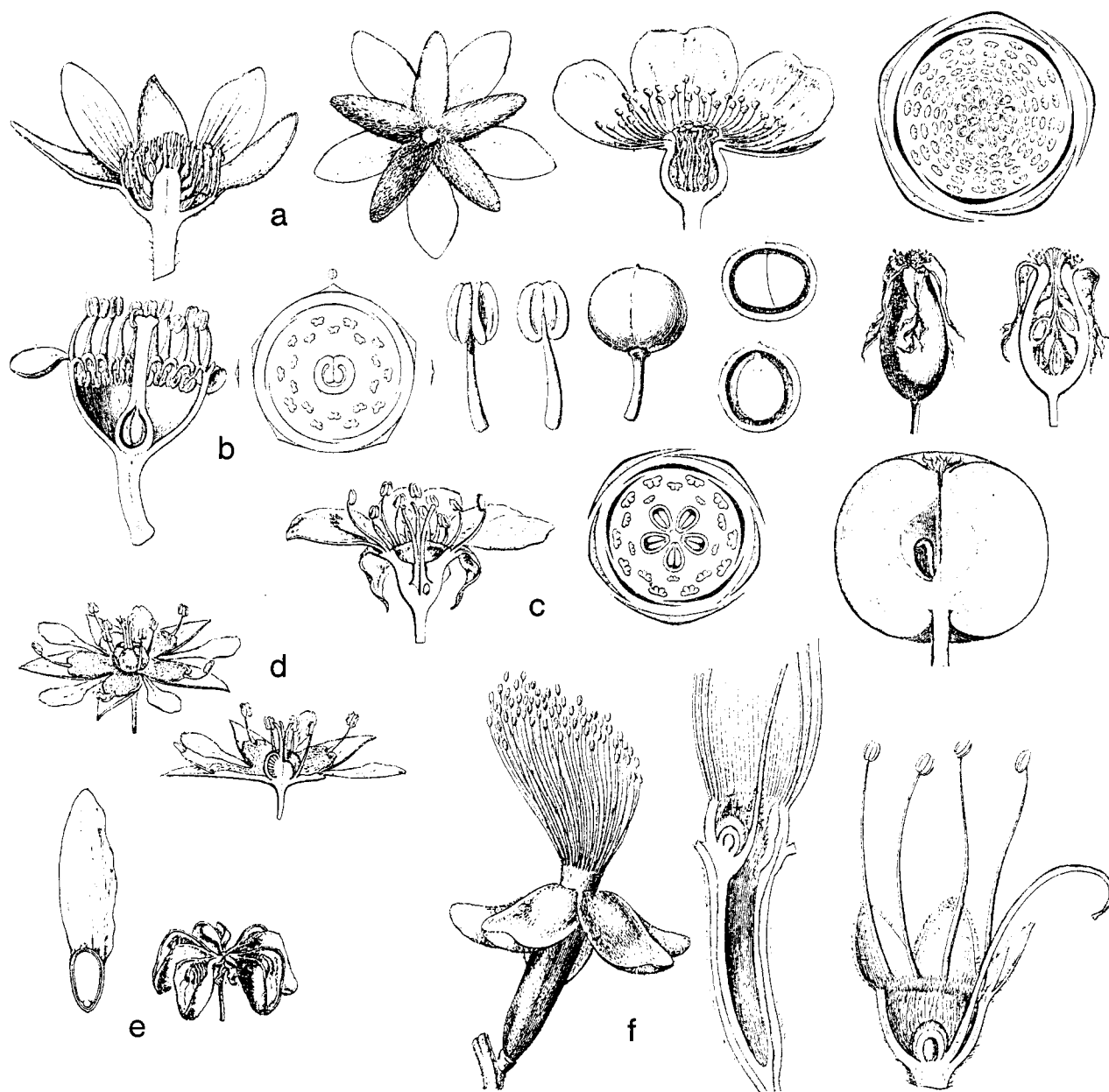


FIGURE 95.—ROSACEAE: *a*, *Rubus imperialis* l.s. of flower, flower from below, *Rosa pimpinellifolia* l.s. of flower, floral diagram; *b*, *Prunus sphaerocarpa* l.s. of flower, floral diagram, views of stamen, fruit, c.s. and l.s. of same, *Rosa canina* fruit, l.s. of same; *c*, *Pyrus communis* l.s. of flower, floral diagram, *P. malus* l.s. of fruit; *d*, *Quillaja saponaria* flower, l.s. of same; *e*, *Kagneckia oblonga* l.s. of seed, dehiscent fruit; *f*, *Couepia macrophylla* flower with petals fallen, l.s. of same, *Licania utilis* l.s. of flower (after Martius, 1840–1906; Baillon, 1866–1895).

ROSACEAE (Figure 95*a–f*).—Herbs, shrubs, and trees; xylem vessel perforation plates typically simple, but with sporadic multiperforate plates in some species, rarely also scalariform

(*Quillaja*, *Neillia*, *Polylepis*); leaves pinnately compound or simple, alternate or very rarely opposite, mostly serrate, rarely entire, stipulate or rarely exstipulate; inflorescence terminal, race-

mose or cymose, of various types; flowers bisexual or the plants rarely dioecious, the parts hypogynous, perigynous or epigynous, an hypanthium often present; sepals 5 (3–10), imbricate, free or basally connate, an epicalyx sometimes present; petals 5 (3–10) or 0, free, imbricate; stamens often in 1–4 series of 5 or 10 each, sometimes more numerous (to ~400), rarely only 1–4; filaments free or rarely connate (*Chrysobalanus*); anthers small, about as long as wide, dorsifixed; pollen usually 3-colporate; glandular tissue lines the receptacle between the pistils and stamens, sometimes as a disk; pistils numerous (to ~150) to 1, sometimes spirally arranged, the carpels 5 (2–15) in the compound pistils; styles free or rarely connate, the stigmas apical, rarely decurrent ventrally (*Neviusia*), not enlarged; ovary 5(2–15)-locular when compound, the ovules 2 (1–24) per locule, axile, superposed, 1–2-tegmic, crassinucellar, anatropous or semi-anatropous, the funicle short or none; fruit follicles, achenes, drupe(s), pome, rarely a capsule; embryo spatulate, large, straight or rarely slightly bent, linear or folded, sometimes the radicle invested; embryo as long as to 1.3 times the length of the endosperm; cotyledons moderately to markedly thick, rarely convolute, 1–6 times the width of the radicle, 0.6–0.9 the length of the embryo; endosperm mostly scanty or 0, rarely moderate, fleshy.

Composition: ~120 genera, ~2500 species.

Distribution: Cosmopolitan; centered in temperate and subtropical Northern Hemisphere; Chrysobalanoideae are pantropical in lowlands, especially of America.

CORYNOCARPACEAE (Figure 96a,b).—Trees and shrubs; resin canals absent; xylem vessel perforation plates simple; leaves alternate, simple, entire, stipule intrapetiolar; inflorescences terminal and axillary panicles and racemes; flowers bisexual; sepals 5, free; petals 5, shortly adnate to the base of the sepals; stamens 5, the filaments elongated, inserted on the base of the petals and opposite them, alternating with as many petaloid staminodes; anthers about as long as wide; pollen grains bilateral, 2-colporate (?); 5 large disk glands inserted on the staminodes; pistil 1, the

carpels 2, one aborting, the styles 1 (2), stigma capitate; ovary superior, unilocular, the ovule 1, apical, bitegmic, the integuments short, crassinucellar, anatropous; fruit a drupe; embryo large, straight, the cotyledons thick, plano-convex, 0.9 the length of the embryo; endosperm 0.

Composition: 1 genus, 5 species.

Distribution: Northeastern Australia, northern New Zealand, New Guinea, New Hebrides, New Caledonia.

CROSSOSOMATACEAE (Figure 96c).—Shrubs; xylem vessel perforation plates simple; leaves alternate, simple, entire, glaucous, exstipulate; flowers solitary, terminal, deliciously fragrant, bisexual, the parts perigynous; sepals 5 at the edge of an hypanthium; petals 5, free; stamens 15–50, in 3–4 series, the filaments filiform, free; anthers slightly more than twice as long as wide, the filament inserted basally between dorsal and ventral halves, which are separate basally; pollen (2–)3-colporate; disk adnate to the hypanthium; pistils 3–5 (6), the style short, stigma apical, capitate; ovules several, biseriate, ventral, bitegmic, crassinucellar, campylotropous or amphitropous; fruits follicles; seeds with a multifid aril; embryo arcuate, the cotyledons thin, twice as wide as the radicle, 0.6 the length of the embryo; endosperm moderate, about twice the volume of the embryo, fleshy.

Composition: 1 genus, 4 species.

Distribution: Dry habitats; southwestern United States and adjacent Mexico.

NEURADACEAE (Figure 96d,e).—Annual herbs, often woolly, the hairs not stellate; xylem vessel perforation plates simple; leaves alternate, simple, variously lobed or pinnatifid, exstipulate or the stipules minute; flowers solitary, axillary, bisexual, the parts perigynous; calyx tube broad and flat, the lobes 5, \pm valvate, sometimes accrescent, an epicalyx sometimes present; petals 5, separate, inserted on the calyx, in drying turning from yellow to blue-black like some Malvaceae (e.g., *Althaea ficifolia*); stamens 10, in 2 series, the filaments subulate, free; anthers small, bilocular, oblong, dorsifixed; pollen a unique type, 3-armed demicolpi at each pole, and a pore associated with each arm, sometimes 3-colpate,

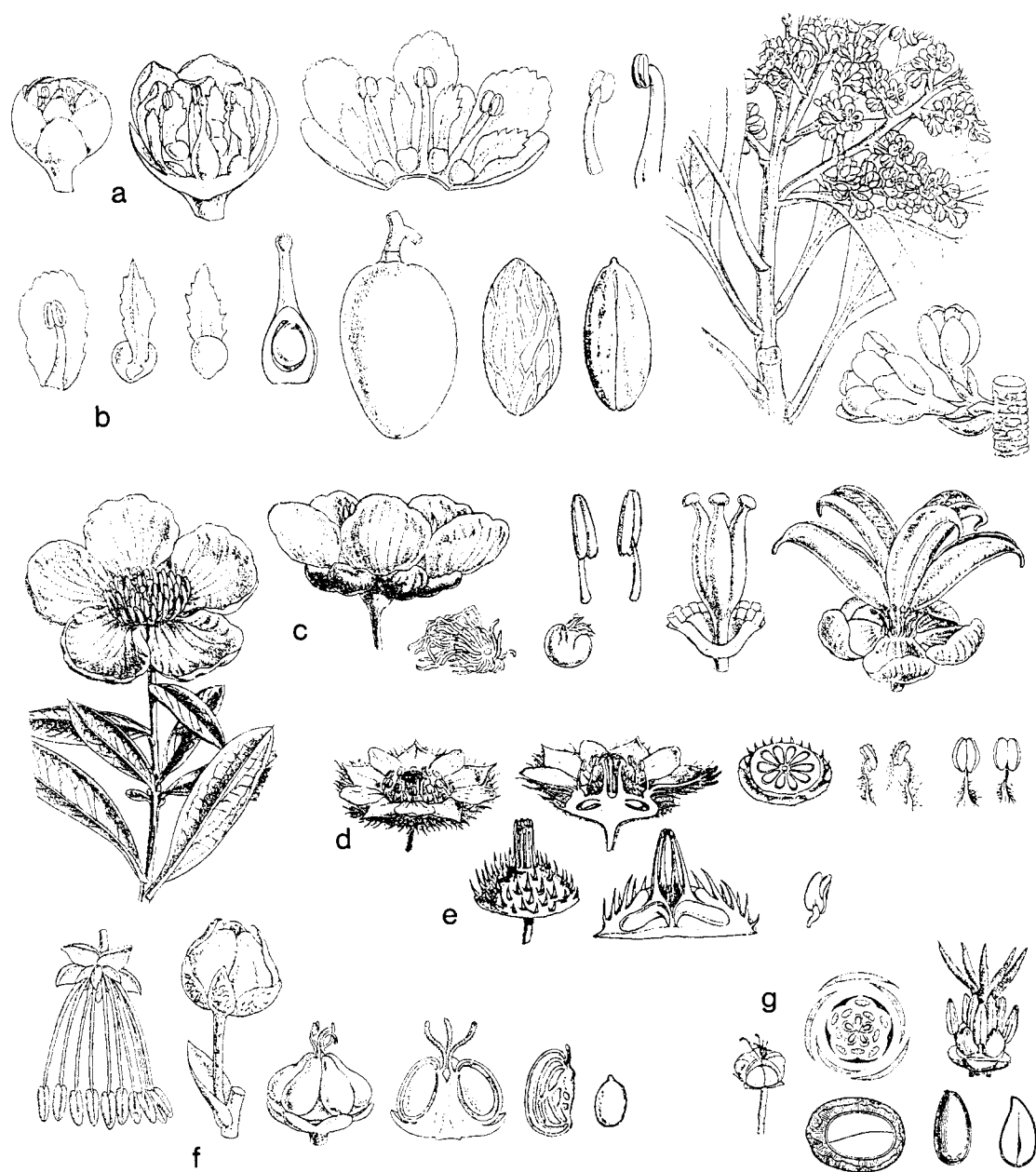


FIGURE 96.—CORYNOCARPACEAE: *a*, *Corynocarpus laevigata* flower, l.s. of same, flower laid open, views of stamen, part of inflorescence and smaller part of same enlarged; *b*, petal with stamen, views of staminode, l.s. of ovary, fruit, seed surrounded by endocarp, embryo (after Cheeseman; Hooker and Hooker, 1837–1982). CROSSOSOMATACEAE: *c*, *Crossosoma californicum* flowering twig, lateral view of flower, seed enveloped in aril and divested of aril, views of stamen, pistil, calyx tube and base of stamens, dehiscent fruit with persistent calyx and stamens (after Hemsley). NEURADACEAE: *d*, *Neurada procumbens* flower, l.s. of same, c.s. of ovary, views of stamen; *e*, fruit, l.s. of same showing the persistent styles, embryo (after Baillon, 1866–1895; Hooker and Hooker, 1837–1906). CORIARIACEAE: *f*, *Coriaria japonica* ♂ flower, ♀ flower, pistil, l.s. of ovary showing ovules, fruitlet, embryo; *g*, *C. myrtifolia* fruit, floral diagram, flower with calyx removed, c.s. of fruitlet, seed, l.s. of same (after Hooker, 1837–1982; Le Maout and Decaisne, 1873).

syncolpate; disk sometimes present; pistil 1, the carpels 3–10 in one series, connate at the ovary level, adnate to the calyx tube; styles 3–10, short, sometimes spinescent, persistent, the stigmas capitate; ovary 3–10-locular, the ovules 1–2 per locule, axile, bitegmic, crassinucellar, anatropous; fruit capsular, the sometimes spinose locules dehiscent ventrally; embryo bent, the cotyledons flattened, auriculate, rather thin, 2–4 times wider than the radicle, 0.5 the length of the embryo; endosperm 0.

Composition: 3 genera, 10 species.

Distribution: Deserts; eastern Mediterranean region to India; southern Africa.

CORIARIACEAE (Figure 96f,g).—Shrubs and small trees, rarely herbs, the buds sometimes perulate; xylem vessel perforation plates simple; leaves opposite, rarely also alternate, or verticillate, simple, entire, major veins extending from the base to the apex, the stipules very caducous; inflorescences axillary or terminal racemes, or the flower rarely solitary; flowers bisexual or the plants monoecious or dioecious, the parts hypogynous; sepals 5 (6), free, imbricate, persistent; petals 5 (6) usually smaller than the sepals, usually with a ventral keel; stamens 10 (12) in 2 series, the filaments filiform, free or those opposite the petals adnate to the keel; anthers large, oblongish, about twice as long as wide, sometimes apiculate; pollen 3–(2–4)-colporate or 3(4)-porate; pistils 5–10 (–12), the styles elongate, papillose, and stigmatic all around for much of their length; ovule 1, ventral and apical, bitegmic, crassinucellar, anatropous; fruitlets achenes, usually enclosed by the accrescent petals that become fleshy; embryo straight, the cotyledons thick, plano-convex, 3 times wider than the radicle, 0.8 the length of the embryo, the transition between them and the radicle is gradual; endosperm scanty or 0.

Composition: 1 genus, ~8 species.

Distribution: Disjunct; Mexico to Peru, Chile; western Mediterranean region, Himalayas to China; Japan to the Philippines; New Guinea to New Zealand.

MYRTALES

Trees and shrubs, sometimes climbing, more rarely herbs; xylem vessel perforation plates simple, rarely also scalariform with a few bars, very rarely exclusively scalariform with 15–60 bars; intraxylary phloem usually present, rarely also interxylary, and vascular tissue in the cortex or pith; tissues sometimes with secretory cavities containing oily substances; leaves opposite, more rarely alternate, simple, usually entire, rarely toothed, lobed or dissected, rarely stipulate; flowers bisexual, rarely unisexual, the parts perigynous or epigynous; sepals 4–5 (0, 2–14, 16), free or connate, imbricate or valvate; petals 4–5 (0, 2–14), free or rarely connate, usually inserted on the calyx tube; stamens usually numerous, 1 to ~400, sometimes 4–10, in 1–several series; staminodes rarely present; filaments free or connate, rarely in bundles, usually inserted on the calyx tube, more rarely external to a disk or epigynous, very rarely adnate to the petals or style; anthers dorsifixed, basifixed or adnate, sometimes didymous, dehiscence longitudinal or by pores, the connective sometimes produced; pollen 3(2–4)-colporate or -colpate, rarely 3-porate, sometimes also with 3–5 pseudocolpi; glandular disk sometimes lining the calyx tube or epigynous, often intrastaminal, more rarely absent; pistil 1, the carpels 2–5 (1(?)–22), styles 1 (3–5), usually elongate, the stigma(s) usually apical, capitate, punctiform or lobed, rarely sessile and radiate; ovary usually inferior or semi-inferior, more rarely superior, 2–5(1–22)-locular, the ovules usually numerous, rarely as few as 1–4 per locule, the placentas axile, rarely apical, free-central, parietal or basal; fruit a loculicidal, more rarely septicidal or circumscissile capsule, berry, drupe, nut, sometimes 3–4-winged, the seeds many, few, or 1; embryo large, straight, arcuate, folded or convolute, the cotyledons terete, flattened or reduced; endosperm absent or scanty, rarely copious.

Distribution: Cosmopolitan, mainly tropical and subtropical, but also common in temperate regions, in a variety of habitats.

Chemistry: Myrtaceae have many terpenoids, largely in the essential oils. Alkaloids are almost unknown in the family, and cyanogenesis is rare, perhaps very rare. Derivatives of ellagic acid are widespread in Myrtales. Ellagic acid occurs in Rosoideae, Myrtales, and elsewhere. Rosaceae and Myrtaceae sometimes have the same alcohols. Myrtaceae have phenolic esters and ethers like Magnoliales. By and large the similarities indicate a close relation between Lythraceae and Myrtaceae, but in contrast to the latter, the former lack leucoanthocyanins. Lythraceae have d-mannitol, a character shared only by Punicaceae. *Heterophyxis* stands out from Myrtaceae.

MYRTACEAE (Figure 97*a,b*).—Trees and shrubs, rarely subscandent or subherbaceous; xylem vessel perforation plates usually simple, *Myrceugenia* and *Myrtus communis* exclusively scalariform with 15–25 bars, also scalariform in young *Eugenia* stem; tissue with secretory cavities usually containing oily substances; vascular bundles bicollateral, intraxylary phloem universally present; leaves simple, entire, very rarely crenulate, opposite, more rarely alternate, glandular-punctate, coriaceous, exstipulate; inflorescences panicles, racemes or dichasial cymes, the flowers rarely solitary; flowers bisexual or rarely the plants polygamous, monoecious or dioecious, the parts perigynous or epigynous; sepals 4–5 (0, 3), free or basally connate, imbricate, valvate, or sometimes calyptrate; petals 4–5 (0, 6), often circular, free or calyptrate; stamens inserted at the margin of a disk, usually numerous (to ~400), rarely only 4–8 and either opposite or alternate with the petals when in one series, the filaments filiform, free or connate basally or in bundles opposite the petals; staminodes rarely present; anthers usually small, about as long as wide to 5 times longer than wide, the connective often with an apical gland, very rarely apiculate (*Acrandra*), dorsifixed or rarely basifixed (*Calothamnus*), dehiscent by longitudinal slits, rarely by apical pores; pollen 3(2–4)-colporate; disk lining the calyx-tube or epigynous; pistil 1, the carpels 2–3 (1(?)–16), the style 1, elongate, stigma apical; ovary usually inferior, sometimes semi-inferior

or superior, the locules 1–3 (–16), the ovules mostly numerous, rarely few or 1 per locule, axile or rarely parietal, 2(1)-tegmic, crassinucellar, usually anatropous, some campylotropous or semi-anatropous; fruit a loculicidal capsule, berry, drupe or nut, the seeds few, very rarely many; embryo straight, arcuate or folded, the radicle sometimes invested; cotyledons linear, foliaceous and flat or variously folded or thick and plano-convex, 1–1.8 times the width of the radicle, 0.2–0.8 the length of the embryo; endosperm 0 or scant.

Composition: 100 genera, 3000 species.

Distribution: Mostly tropical and subtropical, but also numerous in temperate Australia; centered in America and Australia; temperate to tropical Asia, East Indies; New Zealand; southern 2/3 of Africa, Madagascar; Mediterranean region.

LECYTHIDACEAE (Figure 97*c–e*).—Trees and shrubs; xylem vessel perforation plates simple, rarely occasionally scalariform in 2 genera; tissue without secretory cavities; intraxylary phloem absent, but vascular bundles present in the cortex; leaves simple, alternate, entire, not gland-dotted but sometimes with large glands on the margins, exstipulate or very rarely stipulate; inflorescences racemes or corymbs or the flowers solitary, sometimes cauliflorous; flowers bisexual, the parts perigynous or epigynous; calyx 4–6 (2–3)-lobed, the lobes valvate or slightly imbricate; petals 4–6 (8), free or rarely basally connate; stamens very numerous (~60–300) in several series, either monadelphous or diadelphous, often forming a hood over the pistil, part often

FIGURE 97.—MYRTACEAE: *a*, *Eugenia aurata* flowering twig, bud, flower, young fruit, *E. brasiliensis* l.s. of flower; *b*, *Marlierea estrellensis* l.s. of bud, *Eugenia brasiliensis* flower with petals and stamens removed, views of stamen, style, c.s. of ovary, floral diagram, *E. retusus* petal (after Martius, 1840–1906). LECYTHIDACEAE: *c*, *Cariniana estrellensis* flower, bud, petal, views of staminal tube, same laid open; *d*, views of stamen and pistil, c.s. and l.s. of ovary, *Gustavia augusta* floral diagram, l.s. of ovary, stigma (enlarged); *e*, *Couratari rufescens* dehiscent fruit, operculum, *Couroupita surinamensis* c.s. of ovary, seed, same enlarged and partly opened to show embryo, embryo, same laid open (after Martius, 1840–1906).



staminodial; anthers small, about as long as wide, or linear, basifixed or dorsifixed sometimes didymous, dehiscent by slits or pores; pollen 3-colpate, 3-colporoidate, 3-colporate, never syncolpate; disk intrastaminal, and also associated with the stamens and calyx; pistil 1, the carpels 2–6 (7), style 1, rarely 3–4-lobed, short, the stigma(s) apical; ovary inferior or semi-inferior, 2–6(7)-locular, the ovules 1–many per locule, axile, bitegmic, tenuinucellar, anatropous, the funicle often conspicuous; fruit a woody capsule, apically dehiscent, or a berry; seeds large; embryo folded or undifferentiated, the cotyledons foliaceous or conferruminate, 4–5.5 times wider than the radicle, 0.5–0.9 the length of the embryo, the radicle sometimes invested and sometimes much thickened; endosperm 0.

Composition: 15 genera, 325 species.

Distribution: Tropical; centered in rain forest of South America; Central America to the northern $\frac{2}{3}$ of South America.

BARRINGTONIACEAE (Figure 98a).—Trees, rarely shrubs; xylem vessel perforation plates simple, rarely with an occasional scalariform plate; vascular bundles in the cortex; leaves simple, alternate, entire or toothed, exstipulate; inflorescence axillary or terminal raceme or corymb; flowers bisexual, the parts epigynous; calyx 4 (5) (2–3)-lobed, imbricate; petals 4(5) or 0 (*Foetida*), free; stamens numerous (~100–300), the filaments filiform, long-exserted, basally connate, rarely free; anthers small, about as long as wide, basifixed; pollen 3-colpate (syncolpate), 3-colporoidate; disk intrastaminal; pistil 1, the carpels 2–4, the style 1, filiform, often very long, stigma apical; ovary inferior, rarely semi-inferior, 2–4-locular, the ovules 1–several per locule, axile; fruit a fibrous berry, drupe or dry, 4-winged and indehiscent; embryo entire or divided, 0.9 the length of the endosperm; cotyledons 1.5 times wider than the radicle, 0.5 the length of the embryo; endosperm copious.

Composition: 5 genera, 50 species.

Distribution: Palaeotropics; tropical and southern Africa, Madagascar, Hainan, Taiwan, Ryu-Kyu, northern India, Indochina, northeastern Australia.

ASTERANTHACEAE (Figure 98b,c).—Trees and shrubs; xylem vessel perforation plates simple, rarely an occasional scalariform plate in *Asteranthos*; vascular bundles in the cortex; leaves simple, alternate, entire, exstipulate; flowers axillary or cauliflorous, solitary or rarely in a corymb, bisexual; calyx lobes 3 or 5 (10–12 in *Asteranthos*), imbricate or valvate; petals 0; stamens usually numerous (~10–200), in 4 or more whorls, the outermost whorl or all but the inner staminodial and connate into a plicate corona; filaments sometimes filiform, free or basally connate; anthers basifixed, 2–1-locular; pollen 3-colpate, 3-colporate (not syncolpate); disk intrastaminal; pistil 1, the carpels 3 or 5 (5–8 in *Asteranthos*, 5–20(?) in *Napoleonaea*); ovary 3 or 5 (–20?)-locular, semi-inferior or inferior, the ovules several per locule, axile; style elongate, filiform, and the stigma small, or short, flattened apically, and the stigmas 5; fruit a large berry or loculicidal capsule (*Asteranthos*); embryo large, the cotyledons reniform, plano-convex, the radicle very small, endosperm 0(?).

Composition: 3 genera, 20 species.

Distribution: Northern Brazil; tropical west Africa.

DIALYPETALANTHACEAE (Figure 98d,e).—Tree with oil glands in all parts; xylem vessel perforation plates simple(?); leaves simple, opposite, entire, stipulate; inflorescence a terminal thyrse; flowers bisexual, sweet-scented (like *Jasminum*), the parts epigynous; calyx 4-lobed, the lobes imbricate, rounded; petals 4, in 2 whorls, free; stamens 18 (16–25), in 2 whorls, the filaments short, connate about half way, free from the corolla; anthers elongate, the thecas separate basally, adnate to the connective; pollen 3-colporate; disk fimbriate, surrounding the base of the ovary; pistil 1, the carpels 2, the style 1, stigma apical, very shortly bifid; ovary bilocular, the ovules numerous, axile; fruit a loculicidal and septicidal capsule, partly extending above the persistent calyx; seeds numerous, fusiform; embryo straight, terete, the cotyledons short, radicle small, thick; endosperm scanty, oily.

Composition: 1 genus, 1 species.

Distribution: Tropical eastern Brazil.

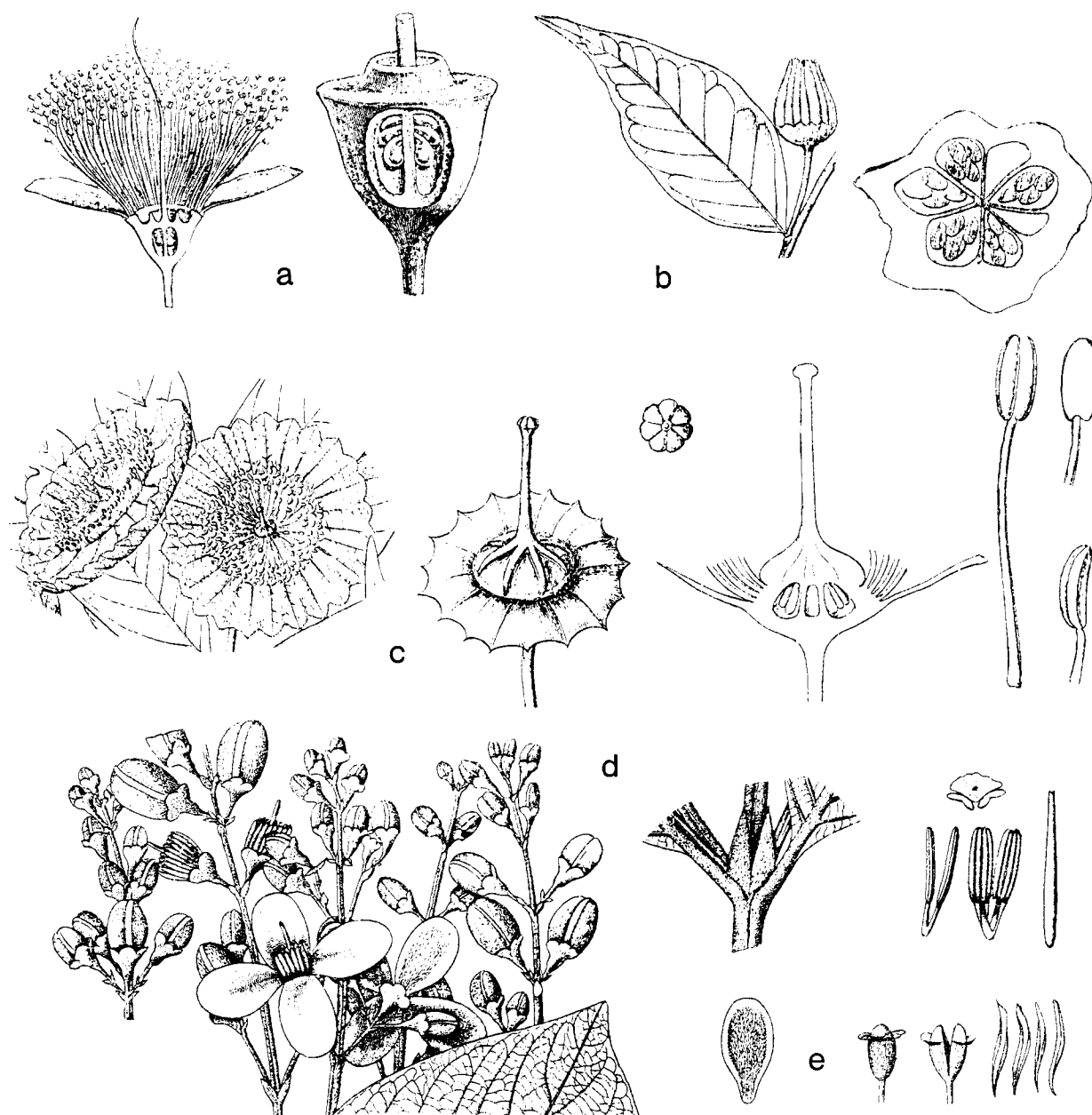


FIGURE 98.—BARRINGTONIACEAE: *a*, *Barringtonia racemosa* l.s. of flower, ovary opened to show the ovules (after Baillon, 1866–1895). ASTERANTHACEAE: *b*, *Asteranthos brasiliensis* bud in axil of leaf, c.s. of ovary; *c*, flowers, pistil and calyx, stigma from above, l.s. of flower, stamen, views of anther (after Martius, 1840–1906). DIALYPETALANTHACEAE: *d*, *Dialypetalanthus fuscescens* flowering twigs, base of leaves showing stipules, views of stamen and c.s. of same (above), pistil; *e*, petal, fruit, dehiscent fruit, seeds (much enlarged) (after Kuhlmann).

SONNERATIACEAE (Figure 99*a,b*).—Trees; xylem vessel perforation plates simple; intraxylary phloem present; leaves opposite, simple, entire, coriaceous, exstipulate; inflorescences axillary or

terminal, the flowers solitary or in 3-flowered cymes or corymbs; flowers bisexual or unisexual, the parts perigynous; hypanthium campanulate, thick and coriaceous, the calyx lobes 4–8, valvate,

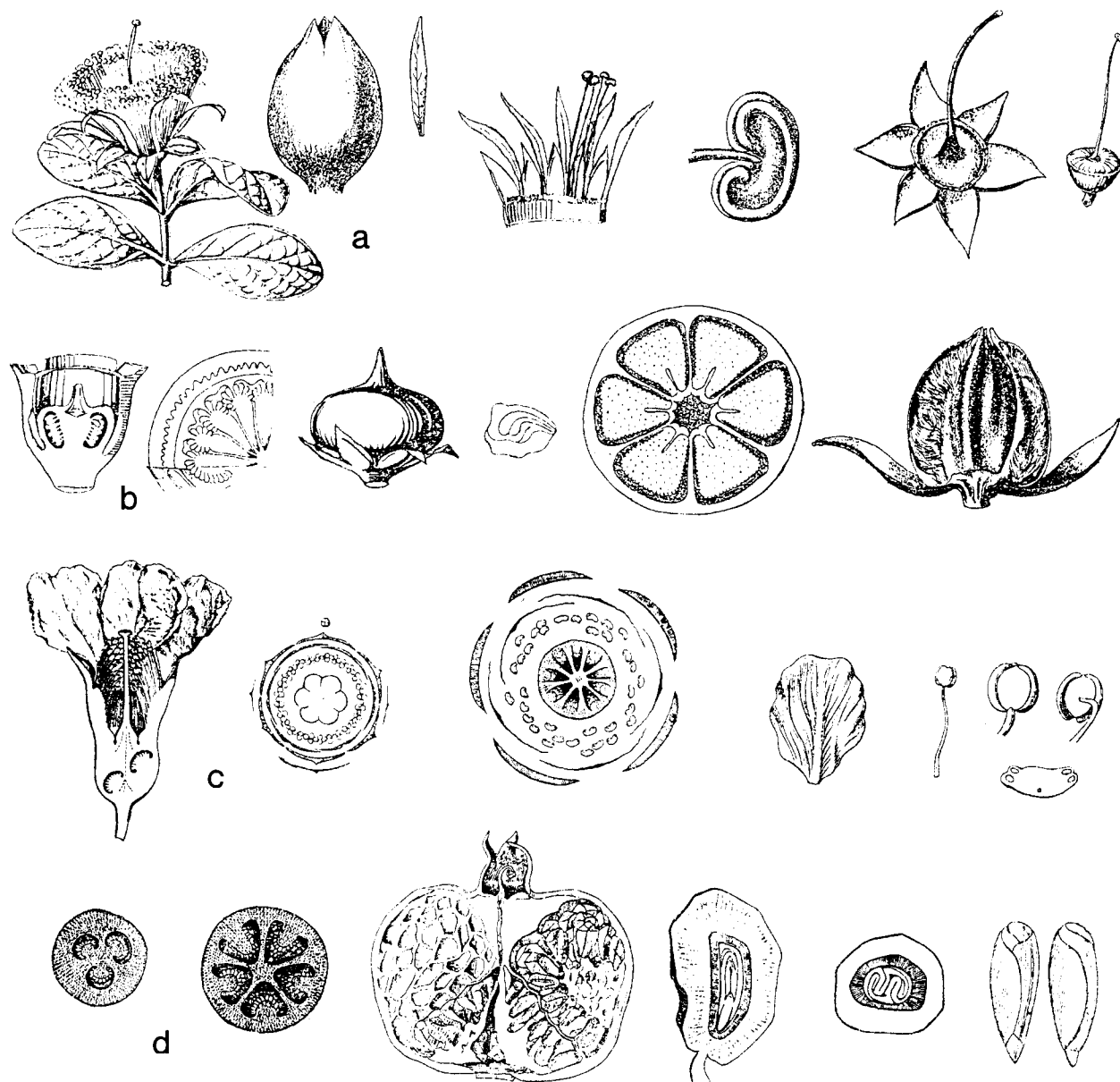


FIGURE 99.—SONNERATIACEAE: *a*, *Sonneratia acidia* flowering twig, bud, petal, part of calyx tube showing insertion of petals and stamens, anther (enlarged), pistil and calyx, pistil; *b*, l.s. of ovary, c.s. of part of same, fruit, l.s. of seed showing the cotyledons, *Duabanga sonneratioides* c.s. of ovary, l.s. of fruit showing the great number of fine seeds (after Hutchinson, 1973; Gagnepain). PUNICACEAE: *c*, *Punica granatum* l.s. of flower, diagram of a 6-merous flower, same of a flower with 5-merous perianth, petal, stamen, views of anther and c.s. of same; *d*, c.s. of fruit at 2 levels, l.s. of fruit, l.s. and c.s. of seed, views of embryo (after Baillon, 1866–1895; Le Maout and Decaisne, 1873; Schnizlein).

persistent; petals 4–8 or 0, free; stamens usually numerous 12 to ~175, in several series, inserted with the calyx lobes and petals at the apex of the hypanthium, the filaments filiform, free; anthers small, reniform, dorsifixed; pollen 3-porate or 3-colporate; pistil 1, the carpels 4–20, the style 1, elongate, the stigma capitate; ovary 4–20-locular, free or adnate basally to the hypanthium, the ovules numerous, axile, bitegmic, crassinucellar, anatropous; fruit a loculicidal capsule or berry, the seeds numerous; embryo arcuate, the cotyledons short, foliaceous; endosperm 0.

Composition: 2 genera, 7 species.

Distribution: Tropical; in a mangrove or in monsoon forest; east Africa, Madagascar; India to Indochina, the East Indies, other western Pacific islands, northern Australia.

PUNICACEAE (Figure 99*c,d*).—Trees and shrubs; xylem vessel perforation plates simple; intraxylary phloem present; leaves mostly opposite, simple, entire, not glandular, exstipulate; inflorescences terminal and axillary, the flowers solitary or in a fascicle, bisexual; hypanthium extending above the ovary, thick, the calyx lobes 5–8, valvate, persistent; petals 5–8, free, crumpled in bud; stamens numerous (~75–125), in several series, inserted with the calyx lobes and petals at the apex of the hypanthium, the filaments filiform, free; anthers small, about as long as wide, dorsifixed; pollen 3(4)-colporate; pistil 1, the carpels 9, the style 1, elongate, stigma capitate; ovary inferior or semi-inferior, the locules 9 in 2 superposed series, the placentas thick, axile in one series, parietal in the other, the ovules numerous, bitegmic, crassinucellar, anatropous, with a long funicle; fruit a berry, the seeds numerous, outer testa fleshy; cotyledons convolute, much broader than the radicle, 0.8 the length of the embryo, the radicle partly invested; endosperm 0.

Composition: 1 genus, 2 species.

Distribution: Southeastern Europe to the Himalayas; Socotra.

RHIZOPHORACEAE (Figure 100*a–f*).—Trees and shrubs; xylem vessel perforation plates scariform with 1–62 bars, simple, or both; intra-

xylary phloem absent; leaves usually opposite, sometimes alternate or whorled, simple, usually entire, sometimes toothed, often coriaceous, sometimes glandular-punctate, the stipules interpetiolar, more rarely absent; inflorescences axillary cymes, racemes, or spikes, rarely the flowers solitary; flowers bisexual or rarely the plants polygamo-dioecious (*Sterigma petalum*) or polygamo-monoecious (*Anisophyllea*), actinomorphic; sepals 3–8 (–14), valvate, often fleshy, persistent, sometimes the calyx-tube extending above the ovary; petals free, perigynous, 3–8 (–14) or 0 (*Pellacalix*), often notched, lacinate or markedly hairy on the ventral surface, convolute or inflexed in bud; stamens 8 (–40), mostly in one whorl, the filaments short or elongate, free or rarely connate basally (*Kandelia*), inserted on the outer edge of a disk, rarely the epipetalous ones adnate to the petals (*Anisophyllea* spp.) or rarely adnate to the calyx-tube (*Pellacalix*); numerous staminodes rarely present; anthers elongate or about as long as wide; 4(2 to ∞)-locular; pollen 3(4)-colporoidate-colporate (sometimes zonate); disk perigynous or epigynous, lobed, rarely absent; pistil 1, the carpels 2–5 (6), the style 1 (3–5), the stigma(s) apical, rarely sessile and 5–6-radiate (*Sterigma petalum*); ovary 2–5(1–12)-locular, sometimes incompletely so, mostly inferior, rarely semi-inferior or superior (*Cassipourea*), the ovules bitegmic, crassinucellar, anatropous or semi-anatropous, 2 (or more) per locule, axile, sometimes subapical, or the placenta free-central in the unilocular ovaries; fruit usually indehiscent, a berry or drupe, or rarely dry and rather hard-shelled (*Anisophyllea*), rarely a septicidal capsule, sometimes 3–4-winged; seeds 1 or 1 per locule, sometimes arillate, rarely winged, often viviparous; embryo small or large, straight, curved or folded; cotyledons 2 (3–4), terete or flat, sometimes connate, usually small, the radicle usually long; endosperm copious, fleshy, or 0.

Composition: 16 genera, 120 species.

Distribution: Pantropical; sometimes a mangrove.

LYTHRACEAE (Figure 101*a–e*).—Trees, shrubs, and herbs; xylem vessel perforation

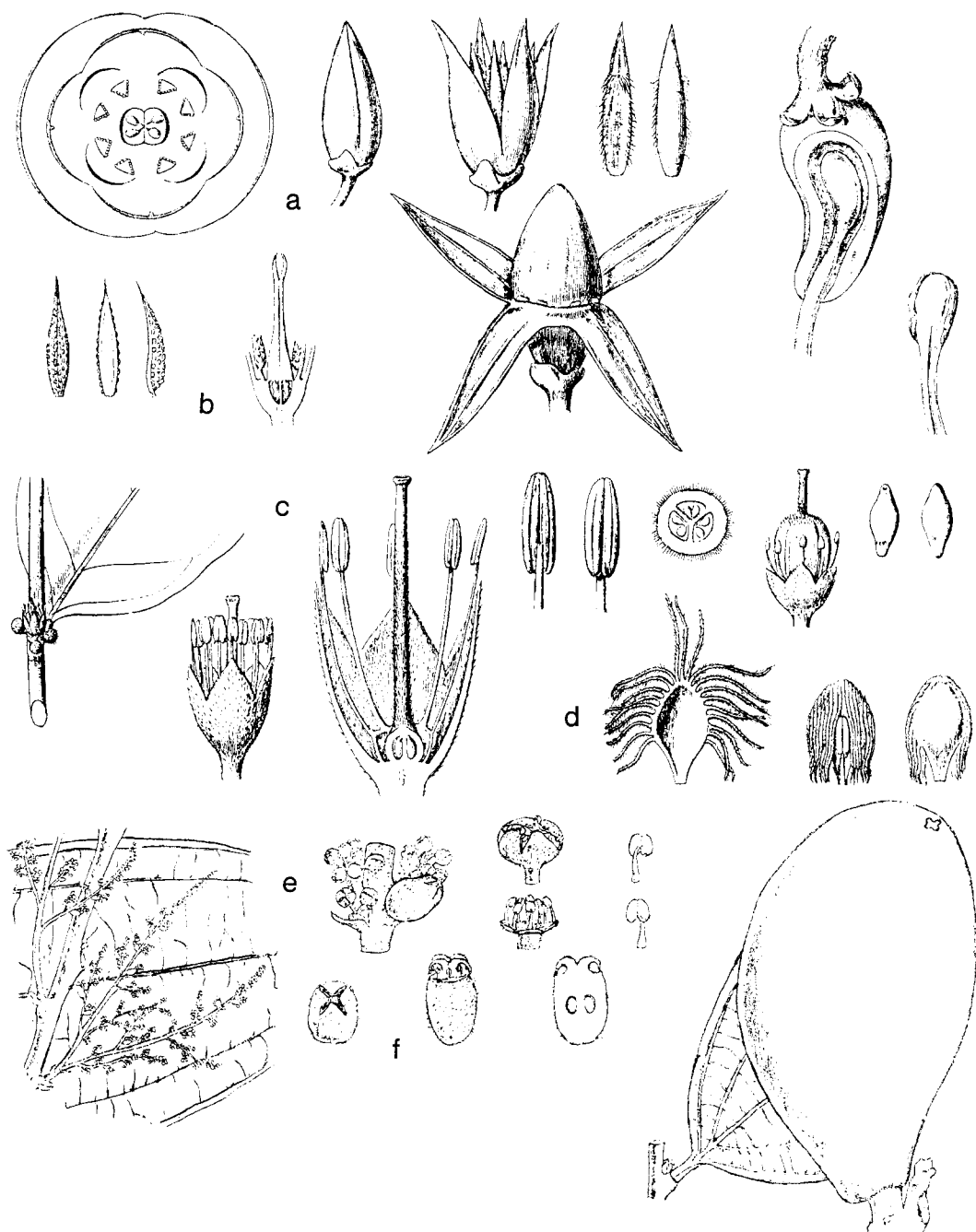


FIGURE 100.—RHIZOPHORACEAE: *a*, *Rhizophora mangle* floral diagram, bud, flower, views of petal, l.s. of fruit with germinated seed; *b*, views of anther, l.s. of base of flower, fruit and calyx, part of embryo; *c*, *Cassipourea guianensis* part of a flowering twig, flower without petals, l.s. of same, views of anther, c.s. of ovary, young fruit with calyx and stamens, views of seed; *d*, petal, views of same (one with stamen); *e*, *Anisophyllea gaudichaudiana* part of flowering twig and leaf, glomerules of ♂ and 1 ♀ flower, ♂ flower and same with perianth removed, views of stamen; *f*, ♀ flower, same with perianth lobes removed, l.s. of ♀ flower, fruit (after Martius, 1840–1906; Oliver).

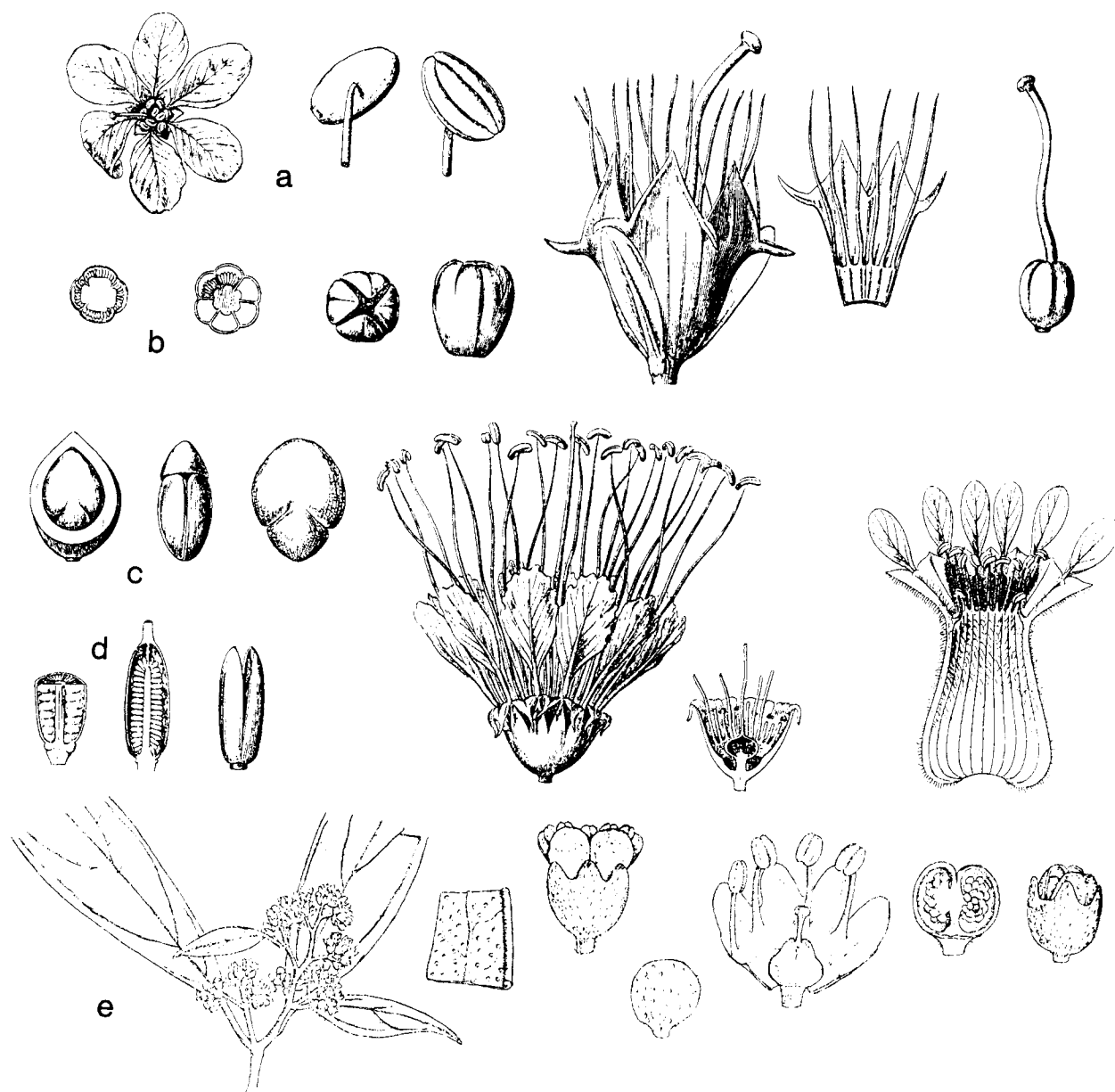


FIGURE 101.—LYTHRACEAE: *a*, *Heimia salicifolia* flower from above, views of anther, lateral view of flower without petals and anthers, part of calyx laid open to show insertion of filaments, pistil; *b*, two c.s. of ovary, dehiscent fruit seen from above and laterally; *c*, *Lythrum hyssopifolia* l.s. of seed, views of embryo; *d*, *L. maritimum* two l.s. of ovary, dehiscent fruit, *Lafoensia vandelliana* flower, l.s. of base of same, *Cuphea longiflora* calyx laid open to show insertion of stamens and petals; *e*, *Heteropyxis canescens* flowering twig, part of leaf margin, flower, petal, flower laid open, the petals removed, l.s. of ovary, dehiscent fruit enclosed in calyx (after Martius, 1840–1906; Oliver).

plates simple; intraxylary phloem present, interxylary phloem rarely recorded; leaves simple, entire, opposite or verticillate, rarely alternate, stipules minute or absent; inflorescences panicles, racemes, dichasia or the flowers solitary; flowers bisexual, the parts perigynous, the pistil and stamens usually trimorphic; calyx-tube often long, the lobes short, 4 or 6 (8 or 16), valvate, often with appendages between the lobes; petals 4, 6 (8 or 0), free, crumpled in bud, inserted at the apex of the calyx-tube; stamens 4–12 (1 to ~200), in 1–2 series, the filaments filiform, often inserted very low on the calyx-tube, below the petals; anthers small, about as long as wide, dorsifixed, rarely basifixed (*Crenea*); pollen 3-colporate, sometimes also with 3 or 6 pseudocolpi, or 3-porate; hypogynous glands sometimes present; pistil 1, the carpels 2–6, the style 1, stigma apical, usually discoid or capitate, rarely bifid (*Adenaria*); ovary superior, often surrounded by an annular disk, (1–) 2–6-locular, sometimes incompletely so at the apex of the ovary, the ovules numerous, rarely to 2 per locule, bitegmic, crassinucellar, anatropous, axile, or rarely on 1 parietal placenta, or basal, or free-central; fruit a capsule, dehiscence circumscissile, valvate, or irregular, or rarely indehiscent (*Peplis*); seeds usually numerous, small; embryo straight, the cotyledons 1.5 times wider than the radicle, 0.45–0.6 the length of the embryo, sometimes investing the radicle; endosperm 0 or rarely scanty.

Composition: ~25 genera, ~500 species.

Distribution: Often in wet habitats; mainly tropical, but also temperate; temperate North America to temperate South America; temperate to tropical Eurasia, the East Indies, Australia, and New Zealand; most of Africa, Madagascar.

CRYPTERONIACEAE (Figure 102 *a,b*).—Trees; xylem vessel perforation plates simple; intraxylary phloem present; leaves opposite, simple, entire, coriaceous, exstipulate; inflorescences axillary racemes or panicles; flowers bisexual or the plants polygamo-dioecious; calyx tubular, the lobes 4–5, valvate; petals 0; stamens 4–5, alternate with the calyx lobes, the filaments filiform, inserted at the apex of the calyx-tube; anthers

small, as long as wide, the thecas separate, adnate to the connective; pollen 2-colporate or col-pate(?); disk 0; pistil 1, the carpels 2, the style 1, elongate, stigma apical, bilobed; ovary superior 2-locular, the ovules numerous, axile; fruit a loculicidal capsule, the valves connected by the persistent base of the style; seeds numerous, minute; embryo terete, straight; cotyledons as broad as the radicle, 0.5–0.6 the length of the embryo; endosperm 0.

Composition: 2 genera, 5 species.

Distribution: Assam, southeast Asia to the East Indies and Philippines.

OLINIACEAE (Figure 102*c,d*).—Trees and shrubs; xylem vessel perforation plates simple; intraxylary phloem present; leaves opposite, simple, entire, the stipules minute; inflorescences terminal cymes; flowers bisexual; calyx tubular, the lobes 4–5, deciduous; petals 5 (4), free, inserted at the apex of the calyx-tube, alternate with 5 colored scales; stamens 4–5, the filaments very short, inserted near the apex of the calyx-tube; anthers small, about as long as wide, didymous, the connective apically produced; pollen 3-colporate, sometimes also with 3 pseudocolpi; disk 0; pistil 1, the carpels 3–5, the style 1, elongate, stigma apical, clavate or capitate; ovary inferior, 3–5-locular, the ovules 2–3 per locule, axile, bitegmic, crassinucellar, semi-anatropous; fruit a drupe, the flesh thin or rarely dry, the pyrenes 1–5; seeds minute, the embryo convolute, one cotyledon longer than the other, the radicle short; endosperm 0.

Composition: 1 genus, 10 species.

Distribution: Tropical eastern and southern Africa; St. Helena.

MELASTOMATACEAE (Figure 103*a–g*).—Shrubs, herbs, and trees, rarely climbing or epiphytic, xylem vessel perforation plates simple; intraxylary phloem universal, sometimes phloem interxylary and in the pith; leaves opposite or verticillate, simple, entire or rarely toothed, mostly with 3–9 longitudinal arcuate, transversely anastomosed veins, penninerved in some Memecyleae, oil glands only in *Microlicia*, exstipulate; inflorescences terminal, axillary or at

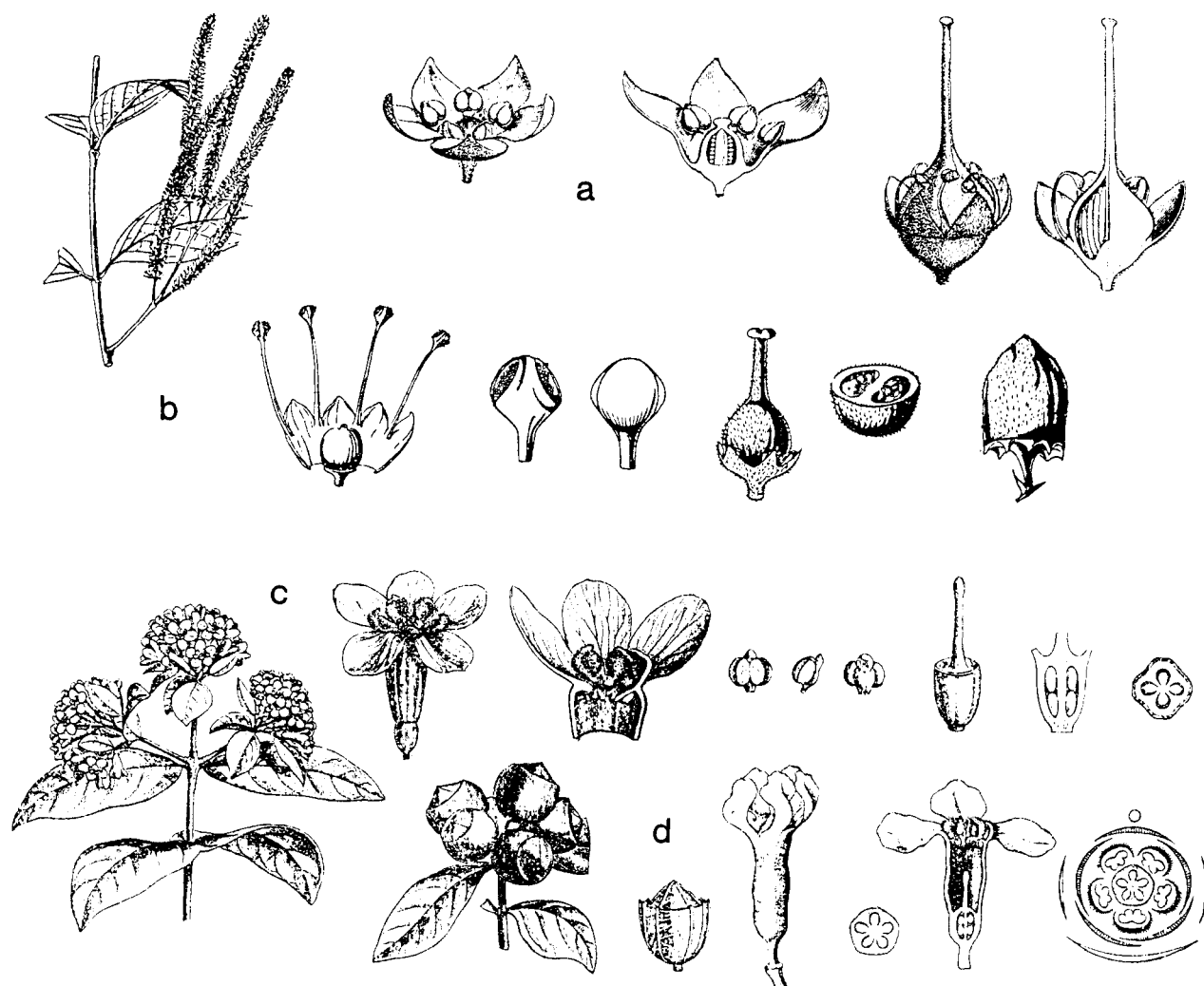


FIGURE 102.—CRYPTERONIACEAE: *a*, *Crypteronia leptostachya* ♂ flower, l.s. of same, *C. javanica* bisexual flower, l.s. of same; *b*, *C. paniculata* flowering twig, flower laid open, views of anther, pistil, c.s. of ovary, fruit (after Baillon, 1866–1895; Hutchinson, 1973). OLINIACEAE: *c*, *Olinia usambarensis* flowering twig, flower, l.s. of upper part of same, views of stamen, pistil, l.s. and c.s. of ovary; *d*, *O. capensis* infructescence, putamen, *O. cymosa* flower, c.s. of ovary, l.s. of flower, floral diagram with 3 bracts (after Gilg; Marloth, 1925; and Link, Klotzsch and Otto).

nodes of fallen leaves, dichasial cymes, corymbiform to paniculate, or the flowers solitary; flowers bisexual or the plants rarely dioecious; calyx tubular or campanulate, often colored, the lobes 4–5 (3–10), imbricate, rarely valvate or calyptrate; petals 4–5 (3–10), free, inserted at the apex of the calyx-tube, usually convolute; stamens 8 or 10 (3–96) in 2 whorls, rarely one whorl staminodial or absent, the filaments elongate, inserted

at the apex of the calyx-tube; anthers usually elongate, frequently curved, often inflexed in bud, basifixed, dehiscence by pore(s), rarely by short slits or completely longitudinal, the connective often appendaged at or near the base of the anther; pollen 3-colporoid plus 3 pseudocolpi; collar sometimes present around the base of the style, nectar rarely present; pistil 1, the carpels 4–5 (2–22), the style 1, elongate, stigma

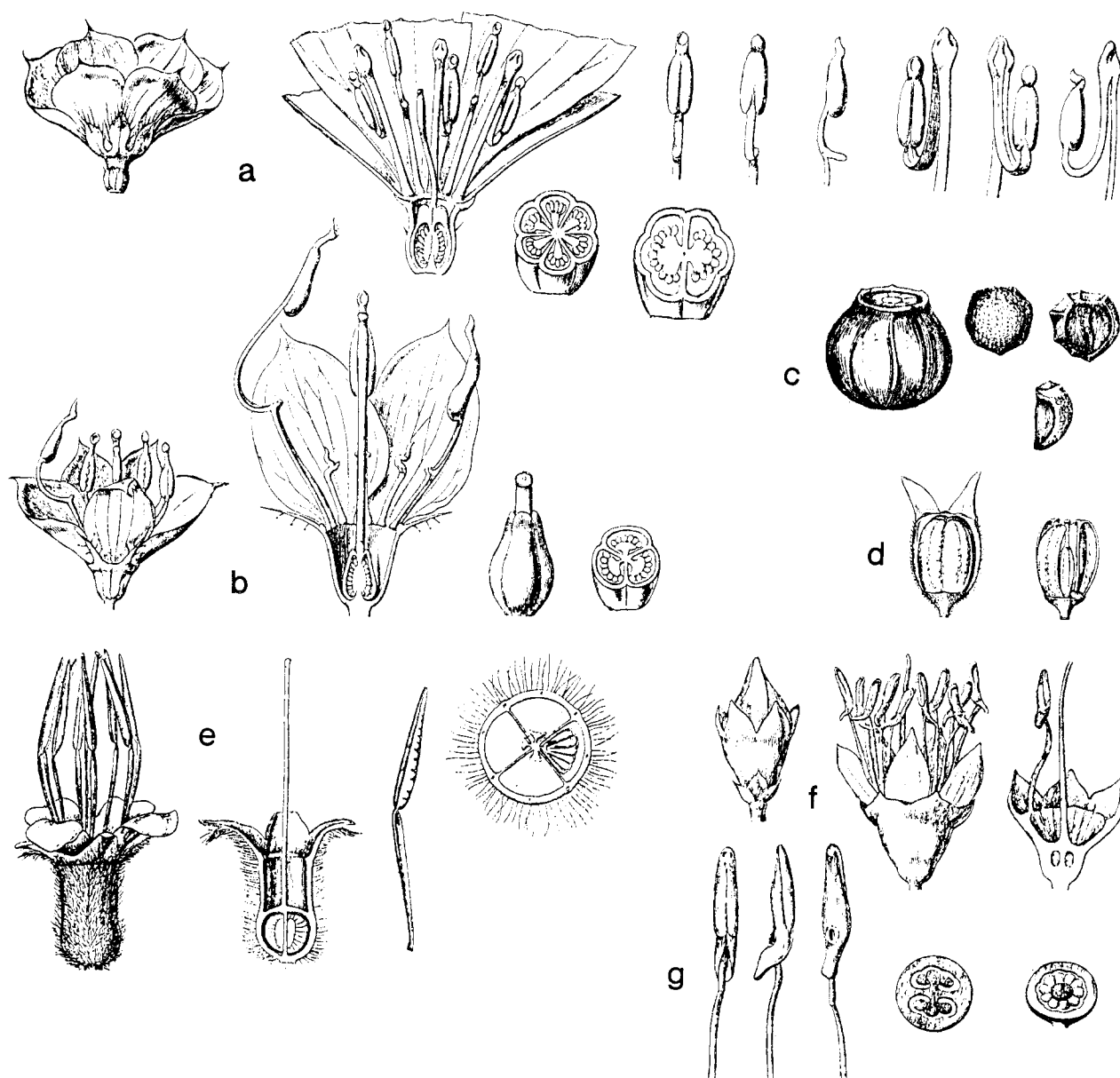


FIGURE 103.—MELASTOMATACEAE: *a*, *Lavoisiera pectinata* flower, l.s. of same, c.s. of ovary, *L. serrulata* c.s. of ovary, *L. pectinata* 3 views of anther of smaller stamen, 3 views of anther of larger stamen; *b*, *Rhynchanthera laxa* flower, l.s. of same, ovary, c.s. of same; *c*, *Miconia ligustroides* fruit, 3 views of seed; *d*, *Marcetia gardneri* fruit and part of calyx, dehiscent fruit; *e*, *Clidemia francavillana* flower, l.s. of ovary and calyx, stamen, c.s. of ovary; *f*, *Mouriri regeliana* bud, flower, l.s. of ovary and calyx; *g*, views of stamen, c.s. of ovary (2 locules), *M. doriana* c.s. of ovary (1 locule) (after Martius, 1840–1906).

apical, often punctiform, sometimes capitate, rarely with as many very short lobes as carpels; ovary superior, semi-inferior or inferior, 4–5 (1–22)-locular, the ovules numerous, rarely few (2–3 per locule in some Memecyleae), axile, rarely basal, or basal-parietal (*Kibessia*), or 6–12 ovules on a free-central placenta in a unilocular ovary (some Memecyleae), bitegmic, crassinucellar, anatropous, sometimes becoming campylo-tropous; fruit a loculicidal capsule or berry; seeds numerous (few in Memecyleae), often minute, the embryo usually arcuate, sometimes straight; cotyledons 0.2–0.4 the length of the embryo, or in Memecyleae large, plano-convex, often conferruminate, or foliose and convolute, the radicle short; endosperm 0.

Composition: 200 genera, ~4500 species.

Distribution: Usually in moist habitats; mainly tropical and subtropical; centered in South America; temperate United States to warm temperate South America; Japan, southern Asia, the East Indies, other Pacific islands, northern Australia; central $\frac{2}{3}$ of Africa.

ONAGRACEAE (Figure 104 *a, b*).—Herbs, rarely shrubs and trees; xylem vessel perforation plates simple, rarely also a few multiperforate plates; intraxylary phloem present, interxylary in a few genera; leaves opposite or alternate, rarely whorled, simple, entire, rarely pinnatifid or the margin sinuate or toothed, rarely stipulate; inflorescences axillary, the flowers often solitary, or in spikes, racemes, rarely panicles; flowers bisexual or rarely the plants polygamous; calyx tube often produced beyond the ovary, often colored, the lobes 4 (2–6), valvate; petals 4 (0, 2–6), free, usually convolute, or imbricate; stamens 4–8 (1–12), usually obdiplostemonous, diplostemonous or haplostemonous, rarely 1 staminodial (*Lopezia*), the filaments elongate, inserted at the apex of the calyx tube or epigynous, rarely adnate to the style; anthers oblong, dorsifixed, dehiscing longitudinally; pollen 3(2–4)-colpate, -colporate, or -pororate; glandular disk often surrounding base of style; pistil 1, the carpels 4 (2–6), the style 1, stigmas 4 (1–6), capitate, notched or radiating branches; ovary 4 (2–6)-

locular, sometimes incompletely so, inferior, rarely semi-inferior, the ovules 1–many per locule, axile, bitegmic, crassinucellar, anatropous; fruit a loculicidal capsule, sometimes apically dehiscent, rarely a berry or nutlet; seeds mostly numerous, but may be only 1; embryo straight or nearly so; cotyledons 0.7–0.9 the length of the embryo, grading gradually into the radicle; endosperm 0.

Composition: 20 genera, ~650 species.

Distribution: Open dry to wet habitats; cosmopolitan except in the larger deserts; mainly temperate and subtropical, centered in western United States and Mexico.

TRAPACEAE (Figure 104 *c, d*).—Floating herbs; xylem vessel perforation plates simple; leaves pinnatisect and opposite when submerged, rhomboid, dentate and with an inflated petiole and in a rosette, and some alternate, when floating, stipulate or exstipulate; flowers axillary, solitary, bisexual, the parts perigynous; sepals 4, basally connate, valvate, persistent; petals 4, free, inserted at the base of the disk; stamens 4, the filaments subulate, inserted at the same level as the petals; anthers small, dorsifixed, longitudinally dehiscent; pollen 3-colpate; disk cupular, surrounding the base of the ovary; pistil 1, the carpels 2, the style 1, elongate, stigma apical, capitate; ovary semi-inferior, bilocular, the ovules 1 per locule, axile-subapical, bitegmic, crassinucellar, anatropous; fruit turbinate, a drupaceous nut, often with 2–4 spines, 1-seeded; seed large, the cotyledons very unequal, one thick and much larger than the other, 4–6 times wider than the radicle, 0.8 the length of the embryo; endosperm 0.

Composition: 1 genus, ~3 species.

Distribution: Temperate to tropical Eurasia and Africa.

COMBRETACEAE (Figure 105 *a, b*).—Trees and shrubs, often climbing; xylem vessel perforation plates simple; intraxylary and interxylary phloem are common; leaves alternate, opposite or rarely verticillate, simple, entire, exstipulate; inflorescences spikes, racemes or panicles; flowers usually bisexual; calyx-tube extending above the

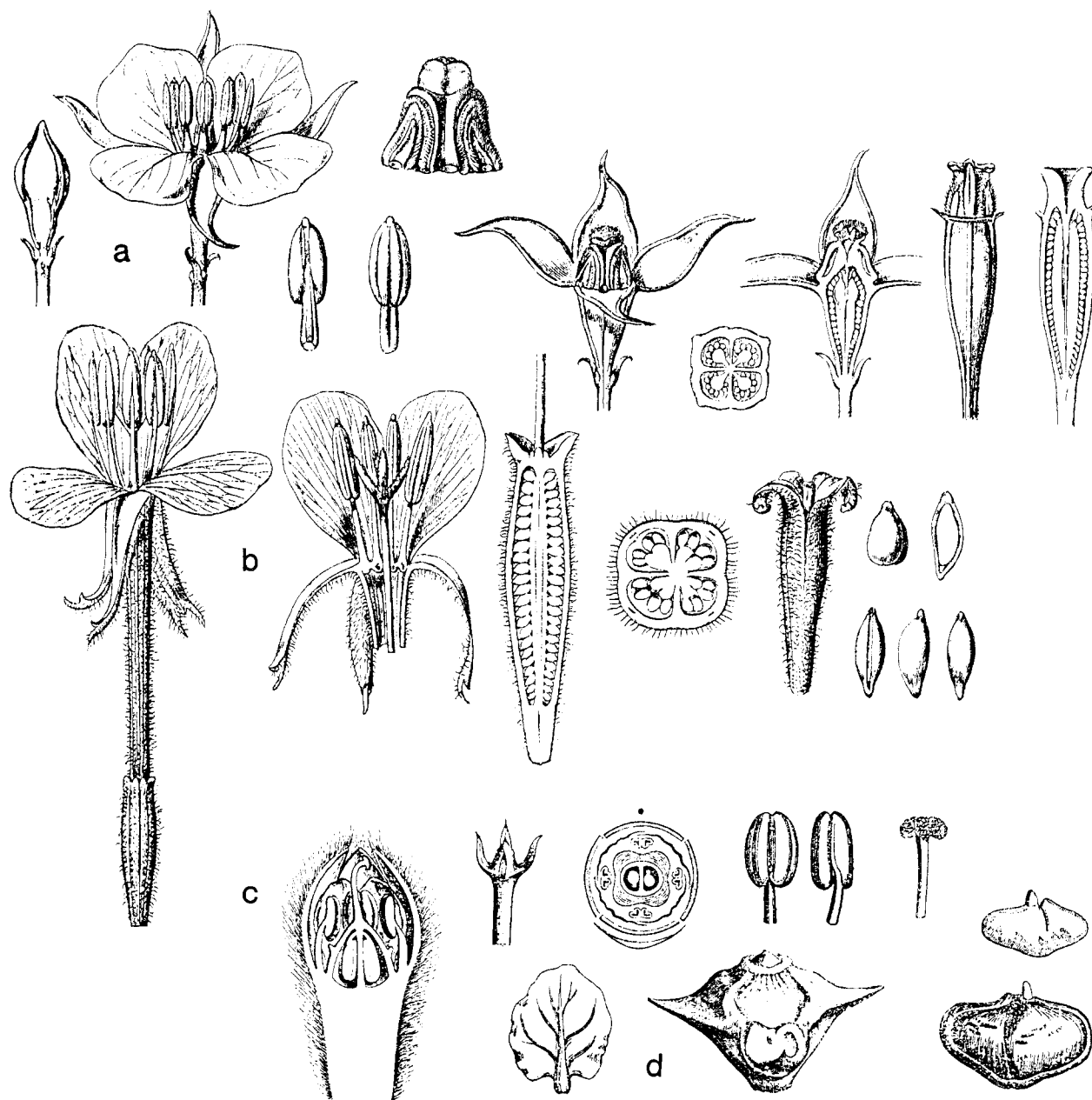


FIGURE 104.—ONAGRACEAE: *a*, *Ludwigia anastomosans* bud, flower, views of stamen, style with disk, flower with petals and stamens removed, c.s. of ovary, l.s. of pistil and calyx, fruit, l.s. of same; *b*, *Oenothera mollissima* flower, l.s. of upper part of same, l.s. and c.s. of ovary, dehiscent fruit, embryo, l.s. of seed and 3 views of same (after Martius, 1840–1906). TRAPACEAE: *c*, *Trapa natans* l.s. of flower, same without the corolla, floral diagram, views of stamen, style and stigma; *d*, petal, fruit, seed and embryo (after Baillon, 1866–1895; Le Maout and Decaisne, 1873).

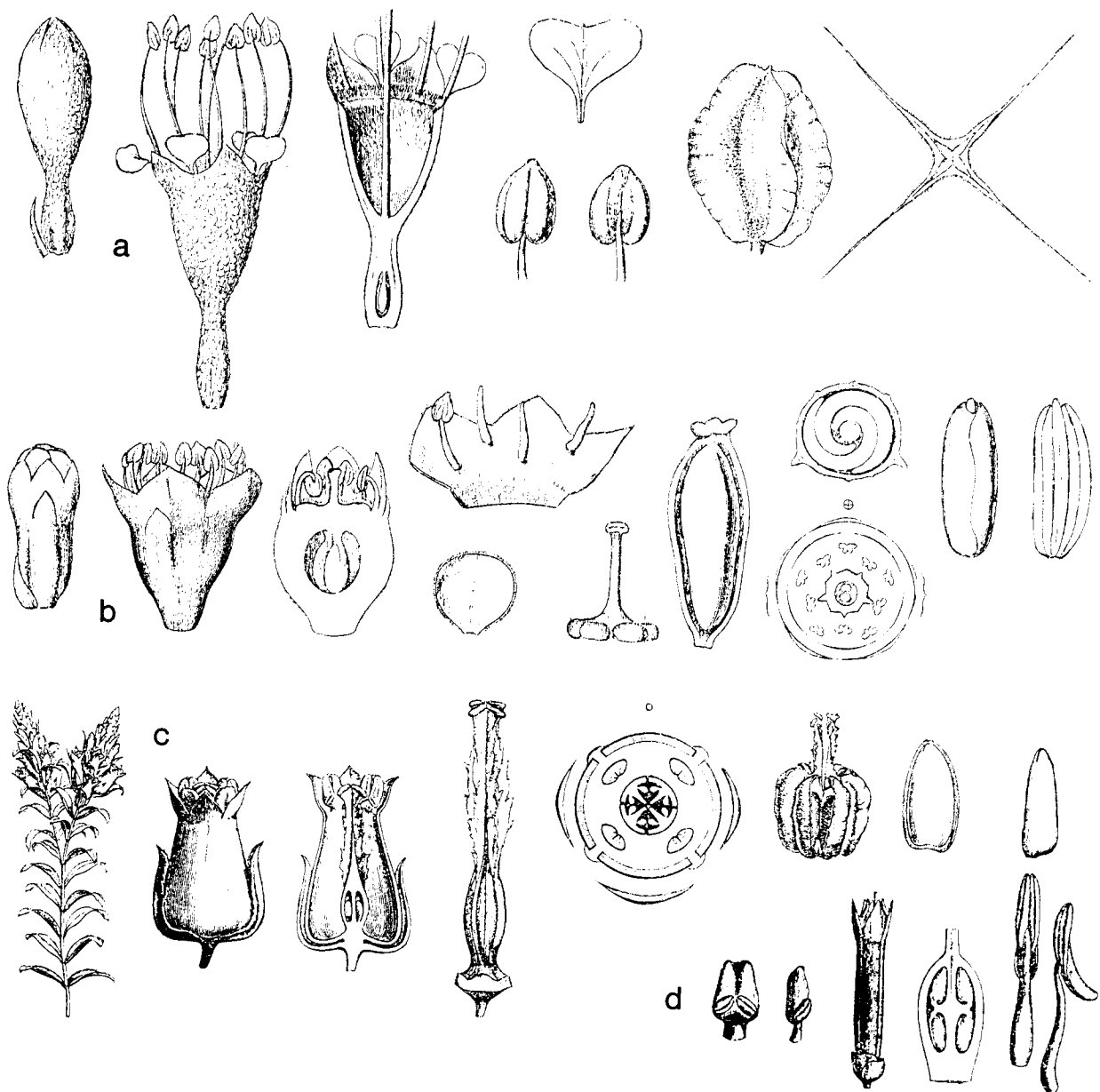


FIGURE 105.—COMBRETACEAE: *a*, *Combretum leprosum* bud, flower, l.s. of same, petal and views of anther, fruit, c.s. of same; *b*, *Laguncularia racemosa* bud, flower without the petals, l.s. of same, part of calyx laid open to show insertion of the stamens and petal, style and epigynous disk, l.s. of fruit showing seed, c.s. of fruit and floral diagram, embryo, l.s. of same (after Martius, 1840–1906). PENAEEACEAE: *c*, *Penaea myrtifolia* flowering twig, flower, l.s. of same, pistil, floral diagram, dehiscent fruit, opened seed, embryo; *d*, *P. mucronata* views of stamen, *Endonema retzioides* flower, l.s. of ovary, views of stamen (after Baillon, 1866–1895; Gilg).

ovary, the lobes 4–5 (6–8), valvate, rarely accrescent, wing-like (*Getonia*); petals 4–5 (6–8) or 0, small, inserted on the calyx-tube external to the disk; stamens 4–10 (–20), mostly diplostemonous, the filaments very long, filiform, inserted on the calyx-tube or external to the disk; anthers small, didymous, about as long as wide, dorsifixed, dehiscent by longitudinal slits; pollen 3-colporate, sometimes also with 3 pseudocolpi; disk epigynous; pistil 1, carpel 1 (reduced from 2–3), the style 1, elongate, stigma(s) apical, capitate or punctiform, 4-lobed in *Laguncularia*; ovary inferior, rarely semi-inferior, unilocular, the ovules 2 (–6), apical, bitegmic, crassinucellar, anatropous; fruit often samaroid, winged at the angles, sometimes drupaceous or nut-like, rarely dehiscent at apex, 1-seeded; embryo straight, the cotyledons foliaceous, coiled or thick, plano-convex, folded longitudinally, or crumpled, 0.9 the length of the embryo; endosperm 0.

Composition: 20 genera, ~550 species.

Distribution: Often in savanna, rarely a mangrove; pantropical, especially Africa, few subtropical.

PENAEACEAE (Figure 105*c,d*).—Small shrubs of ericoid habit; xylem vessel perforation plates simple; intraxylary phloem present; leaves opposite, decussate, simple, entire, coriaceous, the stipules minute or 0; flowers axillary, solitary or paired, often crowded, bisexual, actinomorphic, the bracts often colored; sepals 4, connate, the calyx tubular, persistent, colored, the lobes 4, valvate in bud; petals 0; stamens 4, the filaments very short, inserted near (at) the apex of the calyx-tube; anthers about as long as wide, basifixed, dehiscent longitudinally; pollen 3(–5)-colporate and with 3–5 pseudocolpi; disk 0; pistil 1, the carpels 4, the style 1, elongate, stigma capitate or 4-lobed; ovary superior, 4-locular, the ovules 2–4 per locule, axile or basal, bitegmic, crassinucellar, anatropous, the embryo sac 16-nucleate (*Penaea* type); fruit a loculicidal capsule; seeds often 1 per locule; embryo thick, the cotyledons 0.3 the width of the radicle, 0.1–0.4 the length of the embryo; endosperm 0.

Composition: 5 genera, 25 species.

Distribution: Cape Province, South Africa.

SAXIFRAGALES

Herbs or shrubs, more rarely small trees, sometimes succulent; xylem vessel perforation plates scalariform with few or many bars, simple, or both; leaves alternate or opposite, simple or compound, entire, toothed, rarely lobed, very rarely ascidia, stipulate or exstipulate; flowers bisexual, rarely unisexual, the parts hypogynous, perigynous or epigynous; sepals 4–5 (3–30), free or connate, rarely colored; petals 4–5 (3–30, 0), free or rarely connate; stamens usually in 1–2 whorls of 4–5 each, more rarely numerous or fewer (2, 15, 30, 40, 50 to ~200), usually free, rarely basally connate or adnate to the petals, sometimes inserted on the calyx tube; rarely a whorl of staminodes present; anthers usually dorsifixed, less commonly basifixed, rarely adnate, sometimes didymous, rarely produced apically; pollen usually 3(–11)-colporate, 3-colporoidate, rarely 3-colpate or 2- 4- 8- or 9-pored; glandular disk sometimes present; pistils 1, rarely 2–6, very rarely to 30, the carpels 2–5(–7), styles 1–5(–7), often 2, usually free, the stigmas apical, rarely sessile or decurrent ventrally; ovary superior to inferior, 1–5(–7)-locular, the ovules usually numerous, rarely few to 1 per locule, axile, parietal, ventral, rarely apical or basal; fruit a variously dehiscent capsule, follicles, more rarely a berry, drupe, nutlet or samara; seeds usually numerous, more rarely few, minute; embryo often linear, minute, rarely large and broad; endosperm copious, less frequently moderate, scanty or absent.

Distribution: Cosmopolitan, in various habitats.

Chemistry: Gibbs mentioned that Sedoheptulose, a heptose, occurs in Crassulaceae, Saxifragaceae and *Penthorum*, emphasizing the close relation of Crassulaceae and Saxifragaceae. But it also occurs in various other families.

SAXIFRAGACEAE (Figure 106*a*).—Herbs, rarely fleshy; xylem vessel perforation plates simple; leaves simple or compound, alternate or radical, rarely opposite, exstipulate; inflorescences of various kinds, both racemose and cymose, the flowers rarely solitary; flowers usually

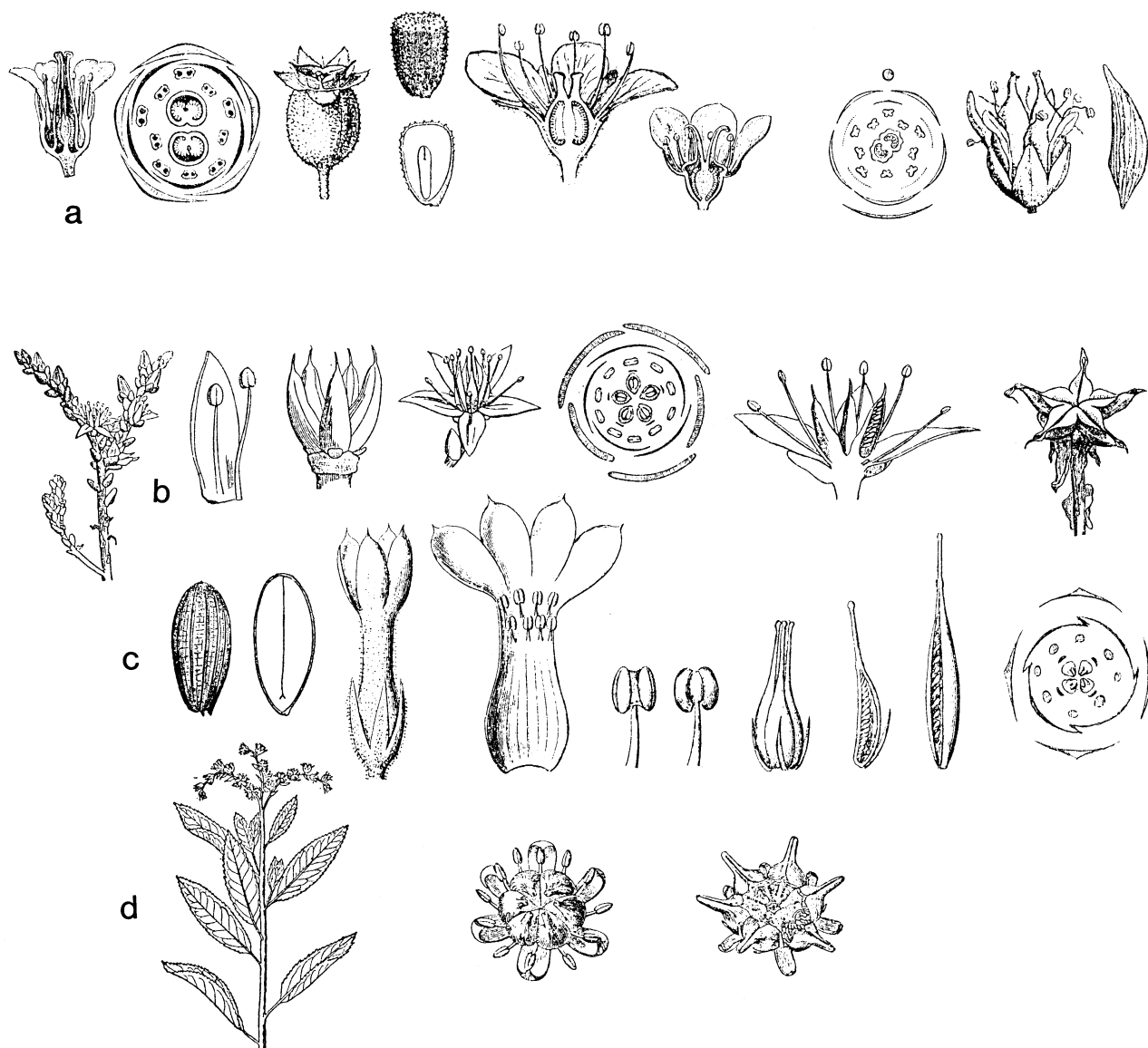


FIGURE 106.—SAXIFRAGACEAE: *a*, *Saxifraga crassifolia* l.s. of flower, floral diagram, *S. tridactylites* dehiscent fruit, seed and l.s. of same, *S. granulata* l.s. of flower, *S. irrigua* l.s. of flower, *Rodgersia podophylla* floral diagram, *Astilbe thunbergii* fruit with residual floral parts, seed (enlarged) (after Baillon, 1866–1895; Engler). CRASSULACEAE: *b*, *Sedum acre* flowering branchlet, petal and 2 stamens, pistils and hypogynous scales, flower, floral diagram, l.s. of flower, fruit; *c*, *Crassula magnoli* seed, l.s. of same, *Kalanchoe brasiliensis* flower, corolla laid open, views of stamen, pistils and hypogynous scales, l.s. of pistil, dehiscent fruitlet, floral diagram; *d*, *Penthorum sedoides* flowering branchlet, flower, dehiscent fruit (after Le Maout and Decaisne 1873; Martius, 1840–1906; Baillon, 1866–1895; Britton and Brown).

bisexual, the plants rarely dioecious (*Astilbe*), the parts hypogynous, perigynous, or epigynous; sepals 5 (4–7), free; petals 5 (4–7) or 0, free or rarely connate; stamens 5–10 (3 in *Tolmiea*), free,

the filaments filiform; anthers small, about as long as wide; pollen usually 3-colporoidate; disk present; pistil(s) 1 (–5), carpels 2 (–5), the styles usually free, stigmas apical; ovary 1–2 (–5)-locu-

lar, the ovules numerous, axile, ventral when the carpels are separate, bitegmic or rarely unitegmic, crassinucellar, anatropous; fruit a septidial? capsule, or rarely follicular; seeds numerous, minute; embryo linear, terete, straight, 0.3–0.7 the length of the endosperm; cotyledons 1–2 times as wide as the radicle, 0.1–0.3 the length of the embryo; endosperm copious, fleshy.

Composition: 30 genera, 600 species.

Distribution: Many alpine and arctic, in dry and moist habitats; almost cosmopolitan; centered in the north temperate zone, few in the Southern Hemisphere.

CRASSULACEAE (Figure 106*b–d*).—Herbs or shrubs, usually succulent; xylem vessel perforation plates simple (scalariform in *Penthorum*); leaves fleshy, alternate, rarely opposite or whorled, sometimes in a rosette, simple, rarely compound, entire or crenate, exstipulate; inflorescences usually cymose, cincinni; flowers bisexual or rarely the plants dioecious, the parts hypogynous to perigynous; sepals 4–5 (3–30), free or connate; petals 4–5 (3–30, 0 in *Penthorum*), free or connate; stamens 4–10 (–60), usually twice as many as the petals, sometimes as many, the filaments filiform, free or rarely basally connate, often epipetalous when the petals are connate; anthers slightly longer than wide; pollen usually 3-colporate; intrastaminal nectariferous scales usually present; pistils 4–5 (3–30), usually as many as petals, sometimes connate basally (*Penthorum*, *Diamorpha*), the styles short or elongate, the stigmas apical; ovary superior, the ovules numerous, rarely few, ventral, bitegmic, crassinucellar, anatropous; fruits follicles, rarely a capsule (*Penthorum*, *Diamorpha*); seeds minute; embryo straight, 0.8 the length of the endosperm, the cotyledons plano-convex, 3 times wider than the radicle, 0.5–0.9 the length of the embryo; endosperm scanty or rarely 0, fleshy.

Composition: ~35 genera, ~1500 species.

Distribution: Mostly in warm dry regions, but also in cool moist ones, and at least one species aquatic; cosmopolitan; centered in South Africa.

PARNASSIACEAE (Figure 107*a,b*).—Herbs; xy-

lem vessel perforation plates simple; leaves mostly or all radical, alternate, entire, exstipulate; flowers solitary, bisexual, the parts hypogynous or perigynous; sepals 5, shortly connate basally; petals 5, free, marcescent, entire or fimbriate; stamens 5, alternating with 5 well-developing often multifid staminodes with nectar-secreting base; anthers longer than wide, dorsifixed, the apex acute; pollen 3-colporate; pistil 1, the carpels 3–4, the style 1, very short, stigmas 3–4, apical; ovary superior or semi-inferior, unilocular, the ovules numerous, parietal, bitegmic, tenuinucellar, anatropous; fruit a loculicidal capsule, the seeds minute; embryo linear, straight, terete, as long as the endosperm; cotyledons 1.0–1.3 times the width of the radicle, 0.1–0.3 the length of the embryo; endosperm scanty or 0.

Composition: 1 genus, 50 species.

Distribution: Chiefly in bogs; temperate Northern Hemisphere.

EREMOSYNACEAE (Figure 107*c,d*).—Annual herb; leaves radical and cauline, entire to pinnately lobed, alternate, exstipulate; inflorescence terminal dichotomous cymes; flowers bisexual, the parts hypogynous or slightly perigynous; sepals 5, nearly free, valvate; petals 5, free; stamens 5, free, the filaments subulate; anthers dorsifixed, small, about as long as wide; pollen 3-colporate (–colporoidate); pistil 1, the carpels 2, the styles 2, filiform, divergent, stigmas apical; ovary bilocular, the ovules 1 per locule, axile near the base of the locule; fruit a capsule, subdidymous, loculicidally dehiscent; embryo apparently oblong; endosperm moderate to copious.

Composition: 1 genus, 1 species.

Distribution: Southwestern Australia.

FRANCOACEAE (Figure 107*e*).—Perennial herbs; xylem vessel perforation plates simple; leaves alternate, subbasal, pinnatifid or rounded-cordate, exstipulate; inflorescences terminal racemes or panicles; flowers bisexual, the parts hypogynous; sepals 4 (5), nearly free, persistent, valvate; petals 4 (5), 2 of which are sometimes smaller than the others or absent; stamens 8, obdiplostemonous or 4 (5) and alternating with glands (staminodes?), the filaments free; anthers

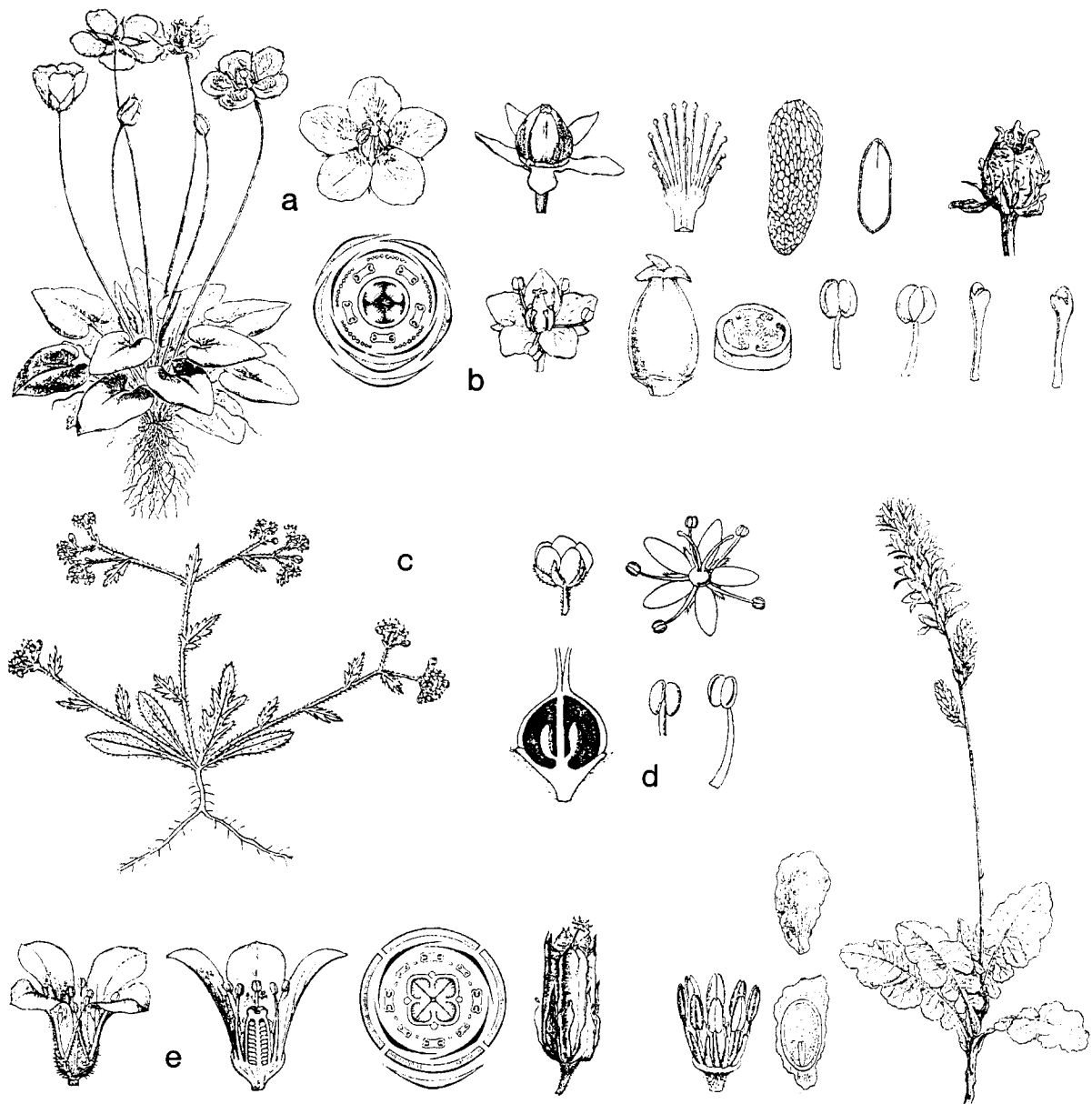


FIGURE 107.—PARNASSIACEAE: *a*, *Parnassia palustris* flowering plant, flower, pistil and calyx, glanduliferous scale, seed, l.s. of same without the testa, dehiscent fruit; *b*, floral diagram, *P. faberi* flower, pistil, c.s. of ovary, views of stamen, staminodes (after Baillon, 1866–1895; Le Maout and Decaisne, 1873; Oliver). EREMOSYNACEAE: *c*, *Eremosyne pectinata* plant in flower, bud, flower; *d*, l.s. of ovary, views of stamen (after Hutchinson, 1973). FRANCOACEAE: *e*, *Francoa sonchifolia* flower, l.s. of same, floral diagram, dehiscent fruit, *F. appendiculata* flower with perianth removed showing stamens and staminodes, *F. ramosa* seed and l.s. of same, *F. appendiculata* plant in flower (after Baillon, 1866–1895; Engler).

oblong, subcordate or didymous; pollen 3-colporate; disk present; pistil 1, the carpels 4 (2), the stigmas 4, sessile, commissural; ovary 4(2)-locular, the ovules numerous per locule, axile, bitegmic, crassinucellar, anatropous; fruit an elongate capsule, dehiscence apically septicidal and slightly loculicidal; seeds very small, striolate, the embryo minute, 0.2–0.3 the length of the endosperm; cotyledons not broadened(?), 0.5 the length of the embryo; endosperm copious, fleshy.

Composition: 2 genera, 2 species.

Distribution: Temperate Chile.

DAVIDSONIACEAE (Figure 108a,b).—Small tree, the indument irritant; xylem vessel perforation plates simple and scalariform; leaves very large, alternate, imparipinnately compound, the leaflets dentate, part of the rachis alate, stipules large; inflorescence axillary or supra-axillary simple or sometimes compound spike; flowers bisexual, the parts hypogynous; sepals 4–5, connate half way; petals 0; stamens 10 and nectariferous scales 10, the filaments \pm tumid below, inserted in a disk; anthers oblong, dorsifixed; pollen 3-colporoidate; pistil 1, the carpels 2, styles 2, free, stigmas minute, terminal; ovary bilocular, the ovules several per locule, axile; fruit a large drupe with 2 leathery pyrenes; seeds 2, large, the embryo large, straight, ovate; cotyledons plano-convex, the radicle very short, endosperm 0.

Composition: 1 genus, 1 species.

Distribution: Tropical and temperate eastern Australia.

HYDRANGEACEAE (Figure 108c,d).—Herbs, shrubs, or small trees, rarely climbers; xylem vessel perforation plates typically scalariform with numerous bars, rarely simple; leaves alternate or opposite, simple, dentate, exstipulate; inflorescences cymes, corymbs or heads; flowers bisexual, sometimes the outer ones sterile and the calyx lobes large and petaloid, sometimes the plants polygamo-dioecious; sepals 5 (4–10) connate or more rarely free; petals 5 (4–10), free or rarely calyptrate (*Pileostegia*); stamens 30, 15, 10, or 8, the filaments filiform; anthers basi- or dorsifixed, linear to short and didymous; pollen 3-colporate; disk 0; pistil 1, the carpels 2–6, the

styles 2–6, free or connate basally or nearly to the apex, stigmas apical; ovary semi-inferior to inferior, 2–6-locular, sometimes incompletely so, the ovules numerous, unitegmic, tenuinucellar, anatropous; placentas axile or intrusive parietal; fruit a capsule dehiscing loculicidally or apically between the styles, or rarely a berry; seeds minute, the embryo linear, straight, 0.4–0.9 the length of the endosperm; cotyledons not broadened, 0.2–0.3 the length of the embryo; endosperm moderate, fleshy.

Composition: 10 genera, 115 species.

Distribution: Mainly north temperate and subtropical; United States, Mexico; Andes to southern Chile; Japan, China, the Himalayas, few in southeastern Asia, Java, and Sumatra.

PHILADELPHACEAE (Figure 108e,f).—Shrubs and small trees, the indument mostly stellate; xylem vessel perforation plates scalariform, simple or both; leaves opposite or verticillate, rarely alternate, simple, serrate or entire, exstipulate; inflorescences terminal racemes, cymes or heads, rarely the flowers solitary; flowers bisexual; sepals 5–4, connate; petals 7–4, free; stamens usually numerous 200–4, the filaments sometimes flattened and toothed toward the apex, free or connate basally; anthers small, about as long as wide; pollen 3-colpor(oid)ate, longicolpate; pistil 1, the carpels 3–7, styles 3–7, free or rarely united into 1; ovary 7–1-locular, superior to inferior, the ovules numerous, rarely 1 per locule (*Whipplea*), axile, rarely parietal or apical, unitegmic, tenuinucellar, anatropous; fruit a septicidal and loculicidal capsule, rarely a berry; seeds minute; embryo linear or subspatulate, straight, 0.9 the length of the endosperm; cotyledons oblong, somewhat flattened, 1–2 times the width of the radicle, 0.2–0.5 the length of the embryo; endosperm moderate, fleshy.

Composition: 7 genera, 135 species.

Distribution: Western North America to Central America; eastern Asia to the Himalayas and Caucasus, Philippines; southern Europe.

PTEROSTEMONACEAE (Figure 109b).—Shrubs; leaves alternate, simple, serrate, stipulate; inflorescences terminal, few-flowered corymb-like



FIGURE 108.—DAVIDSONIACEAE: *a*, *Davidsonia pruriens* inflorescence, part of young inflorescence enlarged, flower, same with stamens removed, pistil, views of anther; *b*, l.s. and c.s. of fruit, 2 views of seed, embryo, cotyledon (after von Mueller). HYDRANGEACEAE: *c*, *Hydrangea virens* inflorescence, flower, *H. hortensis* fruit, seed, l.s. of same; *d*, *H. arborescens* bud, floral diagram, c.s. of ovary, l.s. of seed (after Lindley, 1853; Le Maout and Decaisne, 1873). PHILADELPHACEAE: *e*, *Philadelphus coronarius* flowering twig, flower, l.s. of same, floral diagram, dehiscent fruit, seed, l.s. of same; *f*, *Deutzia scabra* flower, floral diagram, l.s. of flower, *Decumaria barbara* bud, l.s. of flower, c.s. of ovary (after Baillon, 1866–1895; Le Maout and Decaisne, 1873).

cymes; flowers bisexual; calyx lobes 5, valvate, persistent; petals 5, free, persistent; stamens obdiplostemonous, 5 functional and 5 similar but lacking anthers, the filaments flattened, toothed near the apex; anthers about twice as long as wide, dorsifixed, the connective produced apically; pollen 3-colporate; disk absent; pistil 1, the carpels 5, style 1, stigmas 5, apical; ovary inferior, 5-locular, the ovules 6–4 per locule, axile; fruit a capsule septicidally dehiscent apically; seeds 1–few, the embryo long; cotyledons ellipsoid; endosperm moderate, fleshy.

Composition: 1 genus, 2 species.

Distribution: Mexico.

ITEACEAE (Figure 109a).—Shrubs and small trees; xylem vessel perforation plates scalariform with up to 40–70 bars; leaves alternate, simple, dentate or spinose, stipulate; inflorescences terminal or axillary, racemiform or cymes; flowers bisexual or the plants polygamous, the parts perigynous; sepals 5, free, valvate or open; petals 5, free, valvate; stamens 5, the filaments subulate; anthers dorsifixed; pollen 2-porate, 2(3)-por(oroid)ate; disk annular; pistil 1, the carpels 2, style 1, elongated, stigmas apical; ovary semi-inferior, bilocular, the ovules few to many, axile; fruit a septicidal capsule; seeds minute, oblong or scobiform; embryo straight, terete, linear, 0.9 the length of the endosperm; cotyledons not broadened, 0.2 the length of the embryo; endosperm moderate, fleshy.

Composition: 2 genera, 17 species.

Distribution: Tropical and subtropical eastern Asia from Japan to the Himalayas; western Malaysia; temperate eastern North America.

BAUERACEAE (Figure 109c).—Shrubs of wet ground; xylem vessel perforation plates simple, very rarely scalariform with less than 10 bars; leaves opposite, compound, trifoliate, the leaflets serrate, exstipulate; flowers solitary, axillary, bisexual, the parts perigynous; sepals 6–8 (4–10), free or very shortly connate; petals 6–8 (4–10), free; stamens 4–10 (to ~40), in 1–2 series, the filaments free, filiform; anthers small, about as long as wide, didymous, dehiscent by short apical slits; pollen 2-colpate(?), 4 pores; disk thin; pistil

1, the carpels 2, styles 2, free, filiform, recurved, stigmas apical; ovary superior or semi-inferior, bilocular, the ovules 2–several per locule, axile, bitegmic, crassinucellar, anatropous; fruit a subdidymous, compressed, truncate capsule; dehiscence apical and loculicidal; seeds 1–several; cotyledons not broadened, 0.3 the length of the embryo; endosperm copious, fleshy.

Composition: 1 genus, 3 species.

Distribution: Wet habitats; temperate eastern Australia.

BRUNIACEAE (Figure 109d).—Shrubs, often ericoid; xylem vessel perforation plates scalariform, with numerous bars; leaves small, simple, entire, alternate, usually imbricate, mostly exstipulate; inflorescence a terminal spike, raceme, head, or the flowers solitary; flowers bisexual; sepals 4–5, connate or free; petals 4–5, usually free, rarely connate basally; stamens 4–5, the filaments filiform, free or adnate to the petals basally; anthers about as long as wide or linear, dorsifixed, dehiscent longitudinally, the connective sometimes produced apically; pollen 3-, 6–8, 10, 11-colporate; disk rarely present; pistil 1, the carpels 2 (3); ovary semi-inferior or inferior, very rarely superior, 2(1–3)-locular, the ovules 1–4 (–10) per locule, axile near the top of the locule, unitegmic, ? crassinucellar, anatropous; fruit a nutlet or dehiscent into cocci open ventrally; seeds minute, the embryo straight, 0.1 the length of the endosperm; cotyledons not broadened, 0.5 the length of the embryo; endosperm copious, fleshy.

Composition: 12 genera, 75 species.

Distribution: South Africa, especially Cape Province.

VAHLIACEAE (Figure 110a).—Annual or biennial herbs with a taproot; xylem vessel perforation plates simple; leaves opposite, simple, entire, exstipulate; inflorescences axillary, sympodial, cymose, the flowers paired; flowers bisexual, the parts epigynous; sepals 5, valvate; petals 5, free, short; stamens 5, the filaments subulate or linear, sometimes with a basal scale; anthers oblong, slightly longer than wide, dorsifixed; pollen tri-colporate; disk epigynous; pistil 1, the carpels 2

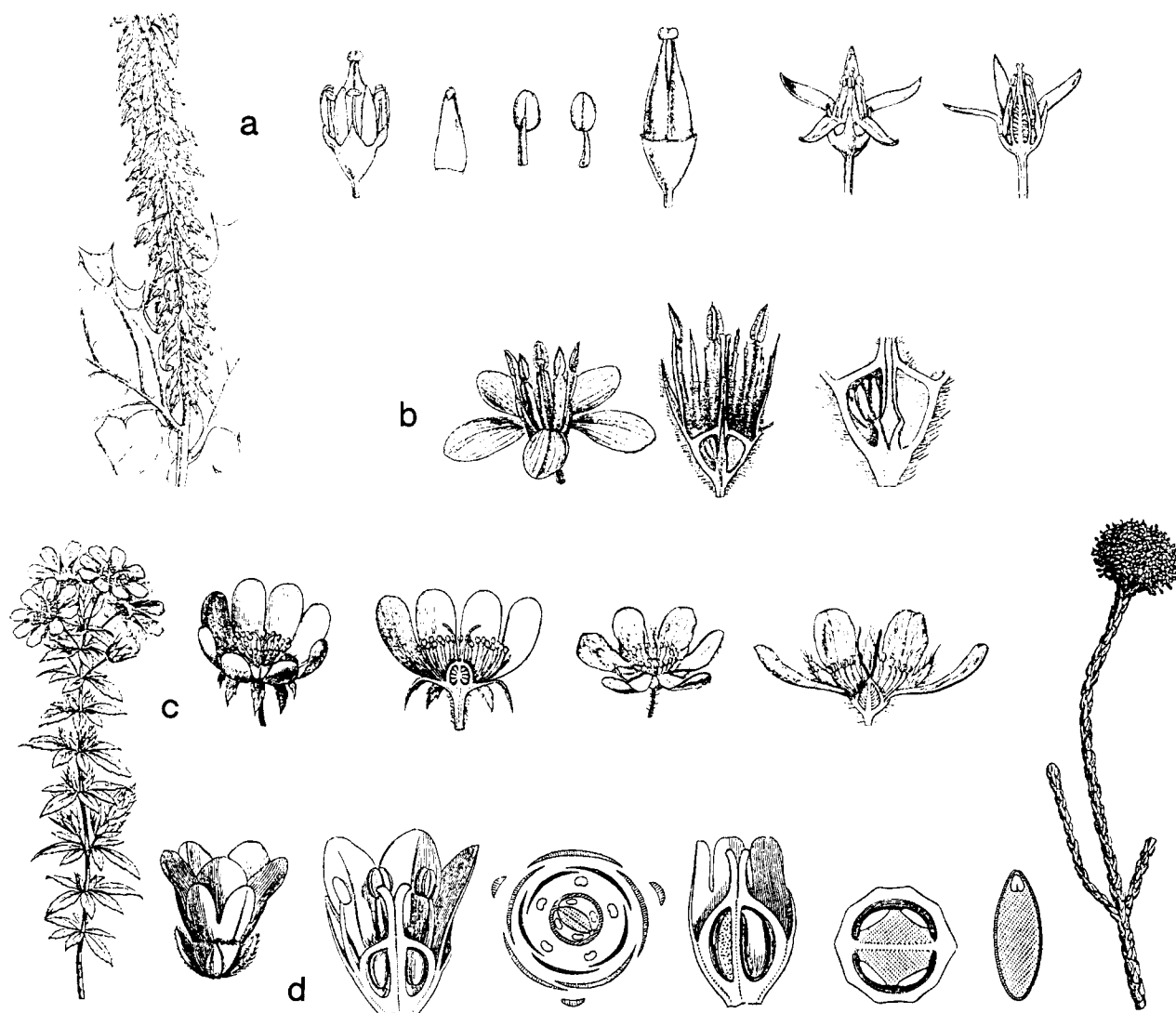


FIGURE 109.—ITEACEAE: *a*, *Itea ilicifolia* half of inflorescence, flower, petal, views of stamen, fruit, *I. virginica* flower, l.s. of same (after Oliver; Baillon, 1866–1895). PTEROSTEMONACEAE: *b*, *Pterostemon mexicanus* flower, l.s. of same (petals removed), l.s. of ovary (after Engler). BAUERACEAE: *c*, *Bauera rubioides* flowering twig, flower, l.s. of same, *B. capitata* flower, l.s. of same (after Baillon, 1866–1895). BRUNIACEAE: *d*, *Brunia pinifolia* flower, l.s. of same, floral diagram, l.s. of fruit, *B. nodiflora* c.s. of fruit, l.s. of seed showing the minute embryo, flowering twig (after Le Maout and Decaisne, 1873).

(3), the styles 2 (3), divaricate, the stigmas apical; ovary unilocular, the placentas 2 (3), suspended from the apex of the ovary, the ovules numerous, bitegmic, tenuinucellar, anatropous; fruit a capsule dehiscent apically between the styles; seeds numerous minute, oblong; embryo 0.75 the

length of the seed, the cotyledons 0.3 the length of the embryo, endosperm copious.

Composition: 1 genus, 5 species.

Distribution: Tropical and subtropical Africa, Madagascar; southwestern Asia to northwestern India.

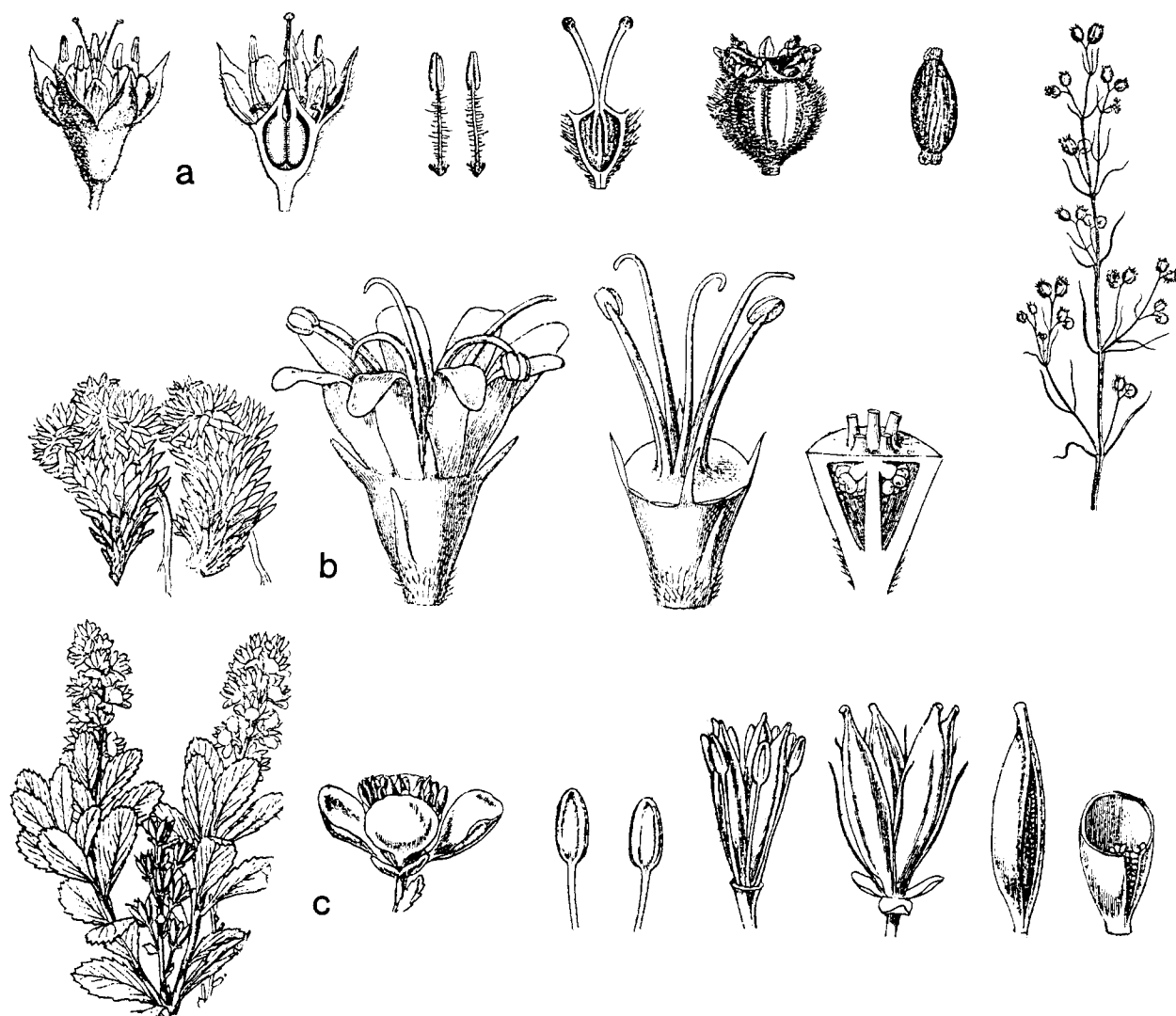


FIGURE 110.—VAHLIACEAE: *a*, *Vahlia capensis* flower, l.s. of same, *V. viscosa* views of stamen, l.s. of pistil, *V. oldenlandioides* fruit, seed, flowering shoot (after Engler). DONATIACEAE: *b*, *Donatia magellanica* plants, flower, same with petals removed, l.s. of ovary (after Hooker and Hooker, 1837–1982). TETRACARPAEACEAE: *c*, *Tetracarpaea tasmannica* flowering and fruiting branch, flower, views of anther, essential organs, fruitlets with persistent filaments and calyx, dehiscent fruitlet, c.s. of same (after Hooker and Hooker, 1837–1982).

DONATIACEAE (Figure 110*b*).—Herbs; xylem vessel perforation plates scalariform, tracheids present; leaves linear, coriaceous, very densely spirally arranged, exstipulate; flowers solitary, terminal, bisexual, the parts epigynous; calyx lobes 5–7; petals 5–10, free, \pm fleshy; stamens 2–3, the filament free; anthers small, about as long as wide; pollen 3(4)-colporate; disk epigynous; pistil 1, the carpels 2–3, the styles 2–3,

stigmas apical; ovary 2–3 locular, the ovules numerous, axile; fruit a turbinate capsule, dehiscence circumscissile; seeds few, with membranous testa; embryo minute; endosperm copious, fleshy.

Composition: 1 genus, 2 species.

Distribution: Tasmania, New Zealand, cool southern South America.

TETRACARPAEACEAE (Figure 110*c*).—Shrubs;

xylem vessel perforation plates simple; leaves alternate, simple, doubly serrate, coriaceous, exstipulate; inflorescence a raceme; flowers bisexual, the parts hypogynous; sepals 4, nearly separate; petals 4, free, orbicular, erose, clawed, caducous; stamens 8, obdiplostemonous, the filaments filiform, anthers basifixed or adnate; pollen 3-colpate(?); pistils 4, the stigmas subsessile, apical, the ovules numerous, ventral; fruit fusiform follicles, the seeds numerous; embryo minute, almost globose, at the base of copious fleshy endosperm.

Composition: 1 genus, 1 species.

Distribution: Tasmania.

ESCALLONIACEAE (Figure 111*a,b*).—Trees and shrubs; xylem vessel perforation plates usually scalariform with less than 20 to 125 bars; leaves simple, alternate, rarely opposite or subverticillate, mostly with gland-tipped teeth, exstipulate; inflorescences mostly racemes, sometimes cymes; flowers bisexual or rarely the plants dioecious or polygamous, the parts perigynous or epigynous; sepals 4–5, mostly basally connate rarely free, imbricate or valvate, often persistent; petals 4–5, free or rarely shortly connate, imbricate or valvate; stamens 4–5 (–9), free, the filaments filiform; sometimes 4–5 staminodes present; anthers dehisce longitudinally; pollen 3-colporate; disk-lobes alternate with the stamens; pistil 1, the carpels 4–5 (2–6), the style 1 (2–6), stigma apical; ovary 1–5(6)-locular, the ovules numerous, axile in multilocular ovaries, parietal in those unilocular, unitegmic (*Escallonia*) or bitegmic (*Brexia*), crassinucellar or tenuinucellar, anatropous; fruit a septicidal capsule, more rarely a berry; embryo linear, straight, 0.4 the length of the endosperm; cotyledons not broadened, 0.15 the length of the embryo; endosperm copious.

Composition: 7 genera, 150 species.

Distribution: Tropical and south temperate; mostly South America, especially Andes, and Australia, Malaysia, Burma; south and east Africa, Madagascar.

GROSSULARIACEAE (Figure 111*c*).—Shrubs, often spiny; xylem vessel perforation plates nearly always scalariform with less than 20 bars, rarely both scalariform and simple; leaves simple,

alternate, lobed and dentate, exstipulate or stipules adnate to the petiole; inflorescences racemes or the flowers subsolitary; flowers bisexual or the plants dioecious; calyx lobes 5 (4), often petaloid, persistent; petals 5 (4), inserted on the calyx-tube, small, often smaller than the calyx lobes, rarely 0; stamens 5 (4), inserted on the calyx-tube; anthers small, about as long as wide, dorsifixed; pollen 8–9-pored; pistil 1, the carpels 2, the styles 2, free to completely connate, stigmas apical; ovary inferior, unilocular, the ovules numerous or few, parietal, bitegmic, crassinucellar, anatropous; fruit a berry, the seeds usually numerous; embryo linear, straight, 0.2 the length of the endosperm; cotyledons not broadened, 0.2 the length of the embryo; endosperm copious, fleshy.

Composition: 2 genera, 150 species.

Distribution: North temperate zone, cool regions of mountains in Central America and the Andes to southern South America; Eurasia, northwestern Africa.

BRUNELLIACEAE (Figure 112*a–c*).—Trees; xylem vessel perforation plates usually scalariform, rarely also simple; leaves opposite or verticillate, pinnately compound, trifoliolate, or simple, usually dentate, stipulate; inflorescences terminal and axillary panicles; plants usually dioecious rarely polygamous or the flowers bisexual; sepals 4–5 (–7), shortly connate, valvate in bud; petals 0; disk adnate to the ovary and calyx; stamens 8–10 (–18), the filaments filiform, free; anthers small, apiculate, twice as long as wide, dorsifixed; pollen 3-colporate; pistils 4–5 (2–3), the styles subulate, stigmas decurrent along ventral surface of style; ovary superior, rarely semi-inferior, the ovules paired, collateral, axile; fruits follicles, often with irritant hairs, separating into exocarp and cartilaginous endocarp; embryo straight, 0.8 the length of the endosperm; cotyledons thin, 3.3 times wider than the radicle, 0.8 the length of the embryo; endosperm copious, fleshy.

Composition: 1 genus, 45 species.

Distribution: Tropical America from Mexico to Peru and Bolivia in the Andes; West Indies.

CUNONIACEAE (Figure 113*a,b*).—Shrubs and trees; xylem vessel perforation plates scalariform

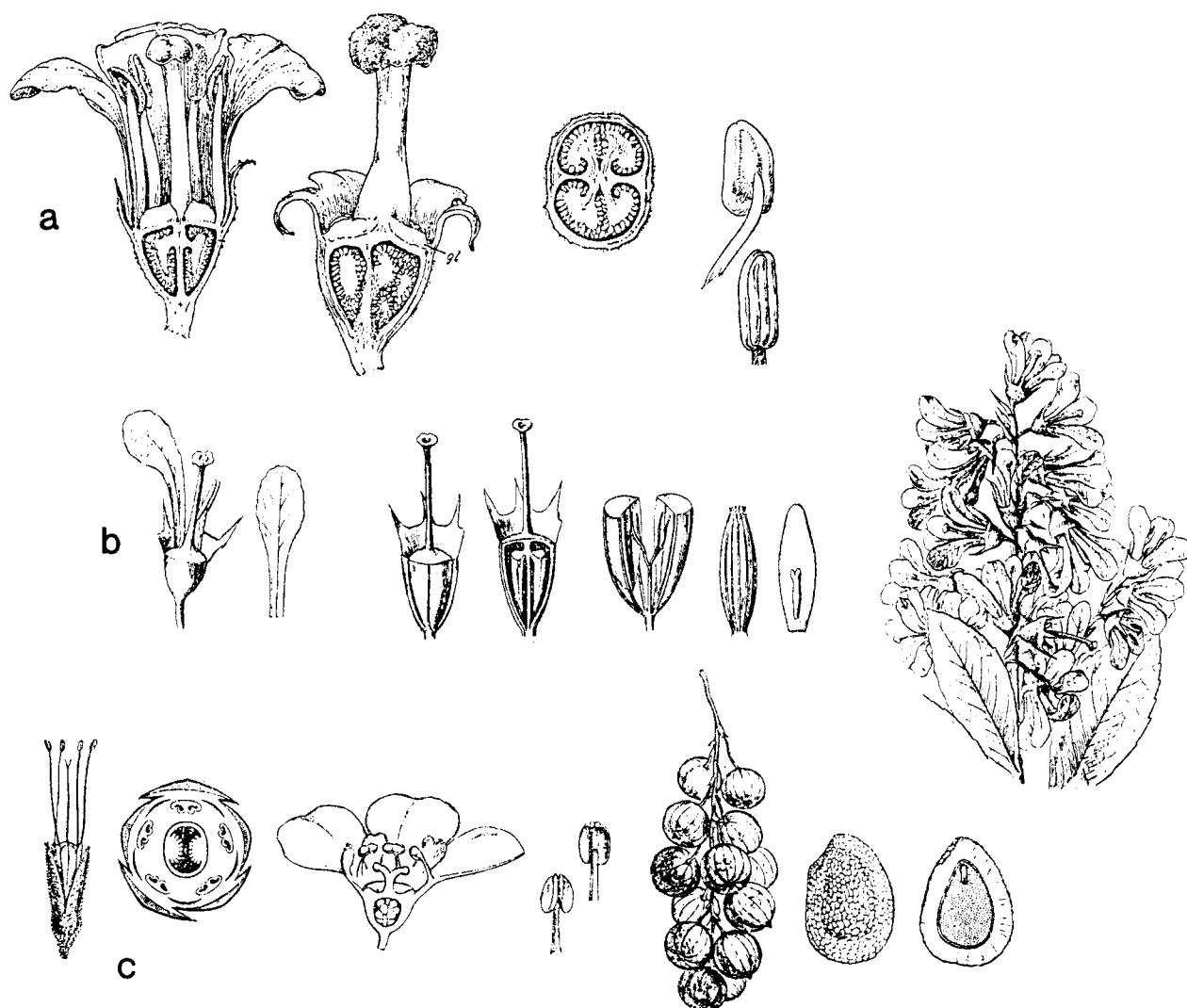


FIGURE 111.—ESCALLONIACEAE: *a*, *Escallonia montevidensis* l.s. of flower, l.s. and c.s. of ovary, views of anther; *b*, *E. chlorophylla* flower with parts removed, petal, fruit, l.s. of same showing the placentas, valve of fruit, seed, l.s. of same, inflorescence (after Johnson; Martius, 1840–1906). GROSSULARIACEAE: *c*, *Ribes speciosum* flower, *R. rubrum* floral diagram, l.s. of flower, *R. nigrum* views of stamen, *R. rubrum* infructescence, seed, l.s. of same showing the minute embryo (after Baillon, 1866–1895; Engler).

with usually fewer than 20 bars, sometimes both scalariform and simple, rarely only simple; leaves pinnately or trifoliately compound, rarely simple, serrate, mostly opposite, rarely verticillate, very rarely alternate if *Gumillea* is included, coriaceous, the stipules often large; inflorescences panicles to heads, or rarely the flowers solitary; flowers small, mostly bisexual, sometimes the

plants dioecious, the parts hypogynous or rarely epigynous (*Ceratopetalum*); sepals 4–5 (3–6), free or basally connate, sometimes accrescent; petals 4–5 (3–6) or 0, free; stamens 8–10 (4 to ~50), the filaments free; anthers small, about as long as wide, dorsifixed; pollen 2–3-colporate or 3-colpate; disk mostly present, often annular, sometimes epigynous; pistils 2 (3–5) or more com-

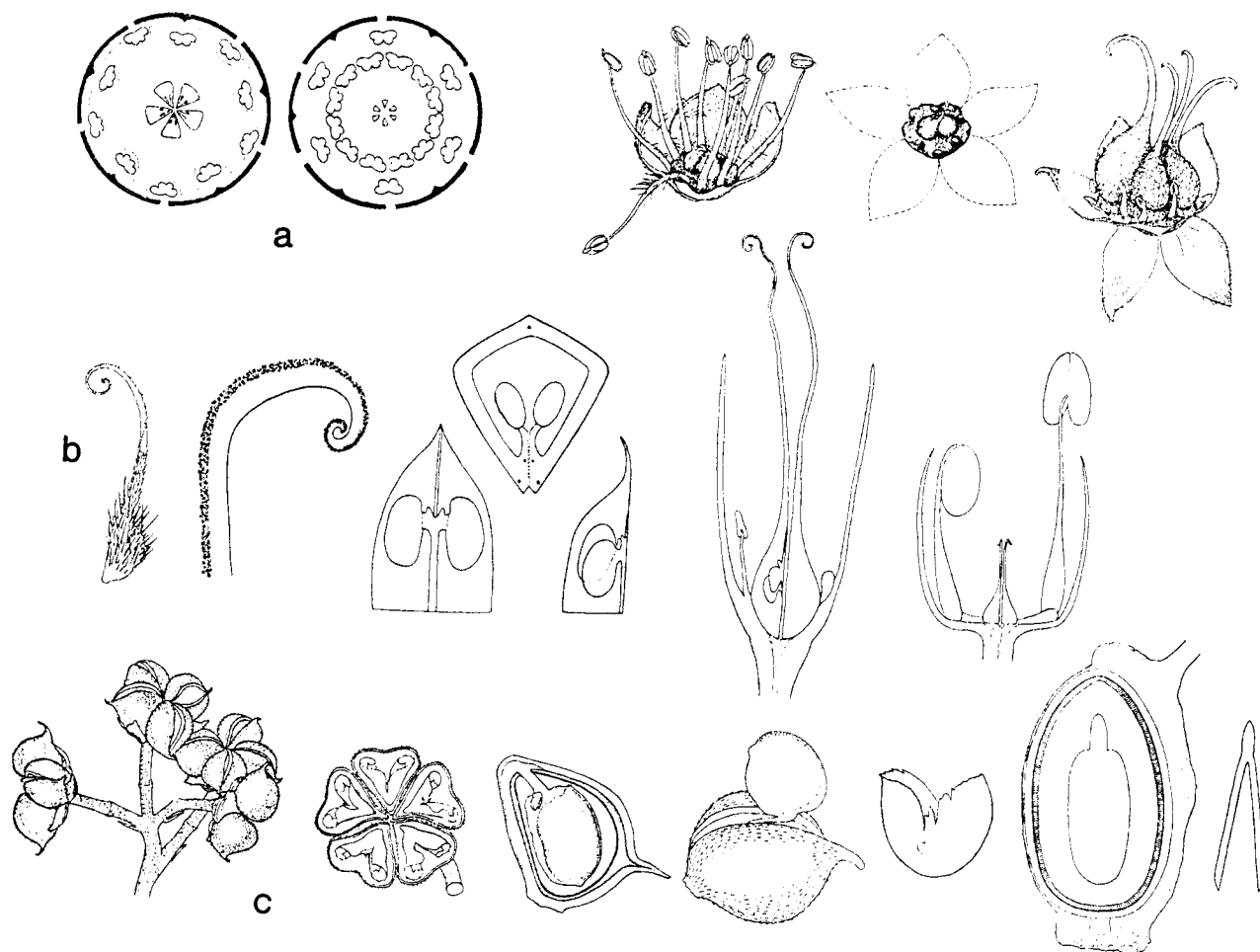


FIGURE 112.—BRUNELLIACEAE: a, *Brunellia sibundoya* floral diagram, *B. pinnata* floral diagram of ♂ flower, *B. colombiana* ♂ flower (2 sepals removed), same with sepals and stamens removed to show the disk and pistillodes, *B. pallida* ♀ flower; b, *B. ovalifolia* pistil, apex of style enlarged to show the decurrent ventral stigma, *Brunellia* sp. ovary laid open to show the collateral ovules, c.s. and l.s. of ovary, *B. ovalifolia* l.s. of ♀ flower, *B. sibundoya* l.s. of ♂ flower; c, *B. standleyana* part of infructescence, dehiscent fruitlets, *B. mexicana* l.s. of fruitlet, *B. costaricensis* dehiscent fruitlet showing the naturally exposed seed, dehiscent endocarp, *B. tomentosa* l.s. of seed, lateral view of embryo (after Cuatrecasas, 1970).

monly 1 and the carpels 2 (3–5), the styles 2 (3–5), free, often filiform, the stigmas apical; ovary superior, semi-inferior or inferior, 2(3–5)-locular when compound, the ovules numerous or few, rarely 1 per locule, axile or apical, bitegmic, crassinucellar, anatropous or semi-anatropous; fruit usually a capsule, dehiscent ventrally, rarely follicles, drupe, nut, or samara; seeds glabrous or long-pilose, sometimes winged; embryo 0.5–

0.7 the length of the endosperm; cotyledons 1.7–4.0 times the width of the radicle, 0.3–0.9 the length of the embryo; endosperm copious, fleshy.

Composition: 26 genera, 250 species.

Distribution: Mostly Southern Hemisphere, especially Australia and Oceania; Malaysia; a few species in South Africa, Madagascar, and southern South America to Mexico and the West Indies.

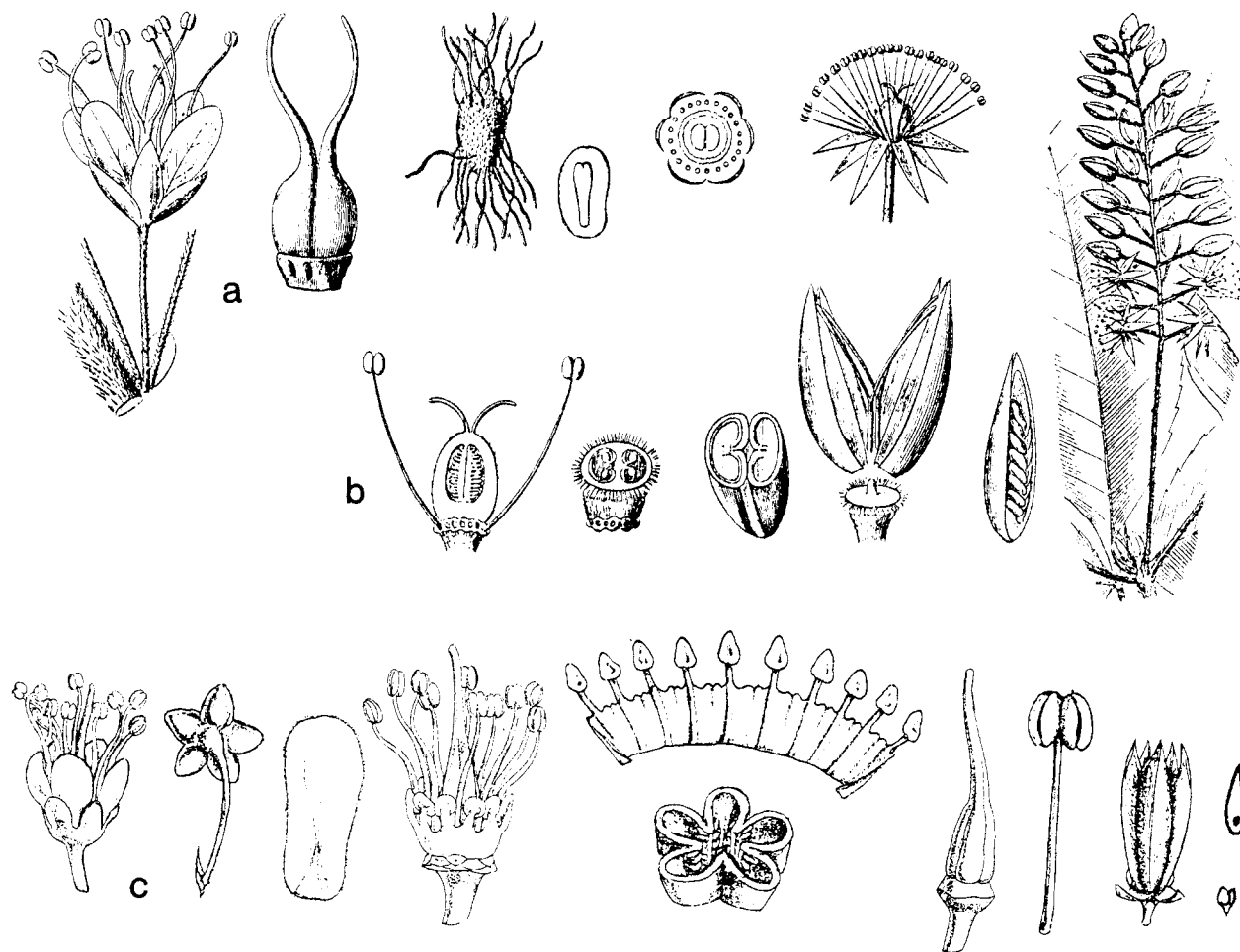


FIGURE 113.—CUNONIACEAE: *a*, *Weinmannia guianensis* flower, pistil, *W. humilis* seed, l.s. of same, *Lamanonia tomentosa* floral diagram, flower; *b*, l.s. of pistil and 2 stamens, c.s. of ovary, c.s. of fruit, valves of fruit, l.s. of fruit valve, inflorescence (after Martius, 1840–1906). GREYIACEAE: *c*, *Greyia sutherlandii* flower, calyx, petal, flower with perianth removed, nectary laid open and c.s. of ovary, pistil, stamen, dehiscent fruit, l.s. of seed and embryo (after Hooker and Hooker, 1837–1982; Harvey).

GREYIACEAE (Figure 113*c*).—Shrubs and small trees; xylem vessel perforation plates simple; leaves alternate, simple, shallowly lobed, toothed, with resinous glands, the petiole adnate to the twig for about 0.6–2.5 cm., exstipulate; inflorescences terminal racemes; flowers bisexual, actinomorphic or slightly zygomorphic; sepals 5, free or very shortly connate, imbricate; petals 5, free, perigynous, imbricate; stamens 10, obdiplostemonous, free, the filaments elongate, filiform; anthers about as long as wide, didymous, basifixed; pollen 3-colporate; disk cupular, exter-

nal to the stamens, coronoid with 10 staminodial appendages, connected to the ovary by 5 interstaminal ridges, secreting abundant nectar; pistil 1, the carpels 5, the style 1, elongate, filiform, stigma punctiform or shortly 5-lobed; ovary superior, unilocular, the ovules numerous on 5 parietal placentas sometimes meeting in the axis, bitegmic, crassinucellar, anatropous; fruit a chartaceous capsule dehiscent along the ventral sutures and also septicidal; seeds numerous, minute, the embryo straight, very small; endosperm copious, fleshy.

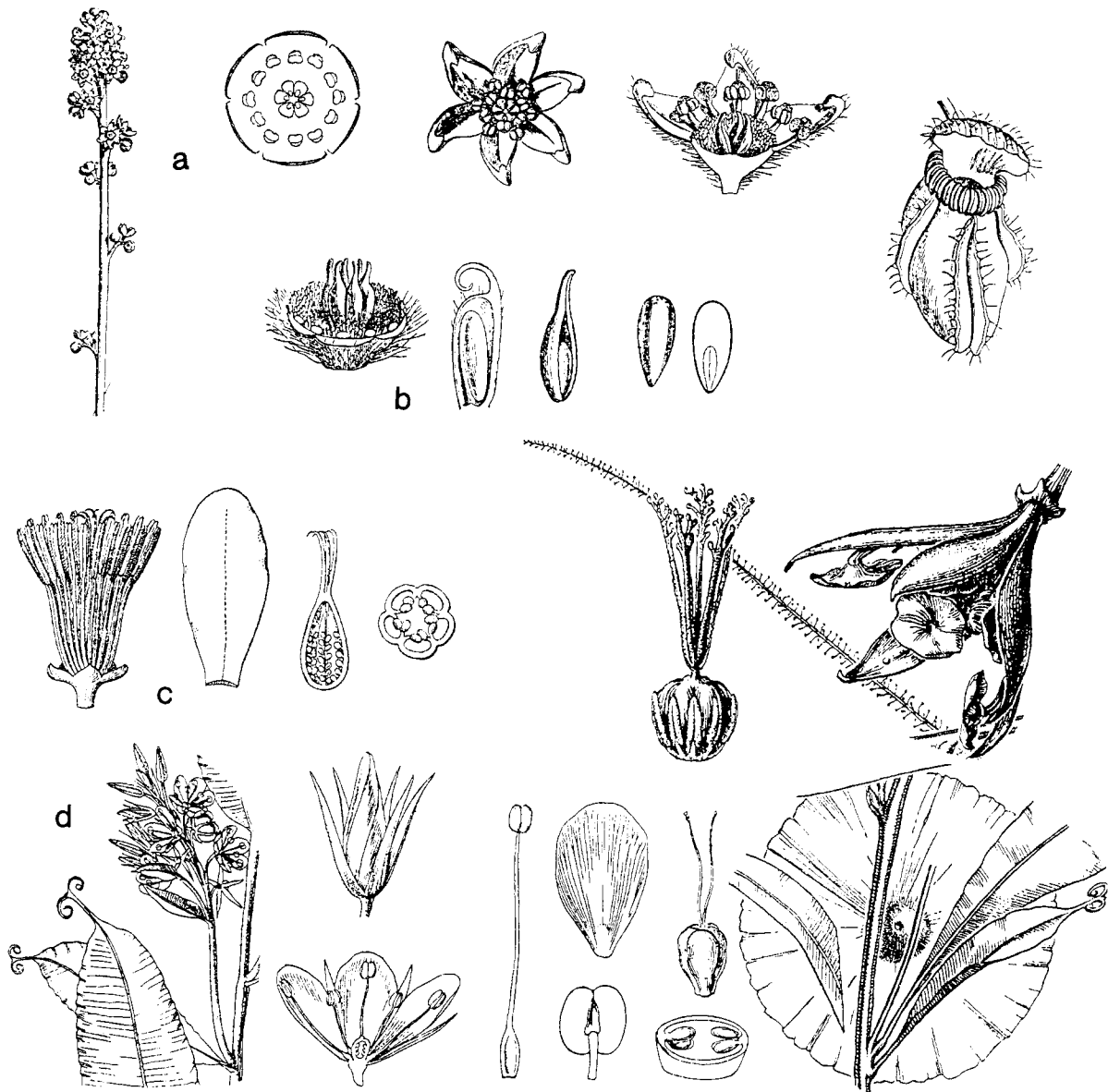


FIGURE 114.—CEPHALOTACEAE: *a*, *Cephalotus follicularis* inflorescence (scapose), floral diagram, flower, l.s. of same; *b*, flower with stamens and calyx removed, l.s. of pistil, dehiscent fruitlet, seed, l.s. of same, pitcher (after Le Maout and Decaisne, 1873). DIONCOPHYLLACEAE: *c*, *Dioncophyllum tholoni* flower with petals removed, petal, l.s. of pistil, c.s. of ovary, *Triphyophyllum peltatum* essential organs, part of a gland-leaf, very young fruit showing young seeds developing on thickened funicles; *d*, *Habropetalum dawei* leaves and part of a flowering twig, bud and l.s. of flower, stamen, petal and anther, pistil and c.s. of ovary, *Triphyophyllum peltatum* mature seed and parts of leaves (after Hutchinson and Dalziel, Gilg).

Composition: 1 genus, 3 species.

Distribution: Southeastern South Africa.

CEPHALOTACEAE (Figure 114*a,b*).—Insectivorous herb of swamps; xylem vessel perforation

plates scalariform; leaves alternate, in a rosette, some flat and entire, others developed into ascidia, exstipulate; inflorescence a terminal raceme of cymules; flowers bisexual, the parts pe-

rigynous; sepals 6, free, valvate, accrescent, colored; petals 0; stamens 12, of 2 lengths, the filaments filiform; anthers small, about as long as wide, produced apically, the connective glandular; pollen usually 3-colporate; intrastaminal disk present; pistils 6, the styles about as long as the ovary, stigma apical; ovule 1 (2), basal, bitegmic, crassinucellar, anatropous; fruit follicles; embryo straight, 0.5 the length of the endosperm; cotyledons plano-convex, twice as wide as the radicle, 0.6–0.8 the length of the embryo; endosperm copious, fleshy, oily.

Composition: 1 genus, 1 species.

Distribution: Southwestern Australia.

DROSERALES

Herbs, less commonly shrublets, sometimes climbing; xylem vessel perforation plates simple, rarely scalariform with numerous bars; leaves alternate, rarely whorled, entire, crenate or pinatifid, sometimes thalloid, often with stalked insectivorous glands, sometimes circinate in bud, exstipulate or stipulate; flowers bisexual, less commonly unisexual; sepals 5 (0, 2–4), free or basally connate; petals 5 or 0 (4), free, rarely shortly connate, hypogynous or very rarely perigynous; stamens 1–10 (–30) in 1 or more whorls, the filaments free or connate, hypogynous or less commonly adnate to the base of the petals; anthers basifixed or dorsifixed, sometimes didymous; pollen sometimes in dyads or tetrads, 3–4-colpate or colpoidate, oligo-12-forate, occasionally 4-rupate, 6-rugate or nonaperturate; pistil 1, the carpels 2, 3, or 5, styles 1, 2, 3, or 5, free or partially connate, the stigmas apical or decurrent, sometimes branched; ovary superior, unilocular, rarely 2- 3- or 5-locular, the ovules usually numerous, rarely few to 1 per locule, parietal, basal, axile or rarely the placentas free-central; fruit a loculicidal or septicidal capsule, the seeds usually minute, rarely large, the embryo minute to large; endosperm copious or absent.

Distribution: Almost cosmopolitan in wet to aquatic habitats.

Chemistry: Naphthaquinones are present in all 4 genera of Droseraceae. Droseraceae may show cyanogenesis. Ellagic acid and quercitin are present in some.

DIONCOPHYLLACEAE (Figure 114*c,d*).—Lianas; xylem vessel perforation plates simple; leaves alternate, entire or crenate, the midrib often excurrent with 2 recurved hooks, sometimes with numerous conspicuous mucilaginous glands, vernation sometimes circinate, exstipulate; inflorescence a lax supra-axillary cyme; flowers bisexual, the parts hypogynous; sepals 5, free or shortly connate; petals 5, free; stamens 10 (–30), the filaments short or long, the anthers basifixed; pollen 3(4)-colp(oid)ate; pistil 1, the carpels 2 or 5, the styles 2 or 5, filiform, free or shortly connate, stigmas apical, sometimes plumose; ovary unilocular, the ovules numerous, parietal, bitegmic, crassinucellar, anatropous; fruit a loculicidal capsule dehiscing before the seeds are ripe; seeds large, discoid, winged; embryo large, spread out, 0.7 the width of the endosperm; endosperm copious.

Composition: 3 genera, 3 species.

Distribution: Rain forest of tropical west Africa.

DROSERACEAE (Figure 115*a,b*).—Herbs, rarely subshrubs (*Drosophyllum*); xylem vessel perforation plates simple, successive bundles of xylem and phloem without regular arrangement; leaves often in rosettes, alternate, rarely whorled, usually circinate in bud and covered with sticky stipitate tentacles or with marginal bristles, stipulate or exstipulate, insectivorous; inflorescences usually circinate cymes (cincinni), rarely racemes or the flowers solitary; flowers bisexual; sepals 5 (4), shortly connate; petals 5 (4), free, hypogynous, very rarely perigynous; stamens 4–20 in 1 or more whorls, hypogynous, the filaments filiform, free or rarely shortly connate, the anthers small, about as long as wide, the thecas sometimes divergent basally and separated by connective; pollen in tetrads except *Drosophyllum*, 6-polyforate; disk 0; pistil 1, the carpels 3 or 5, the styles 3 or 5 (1 in *Dionaea*), filiform, mostly free, the

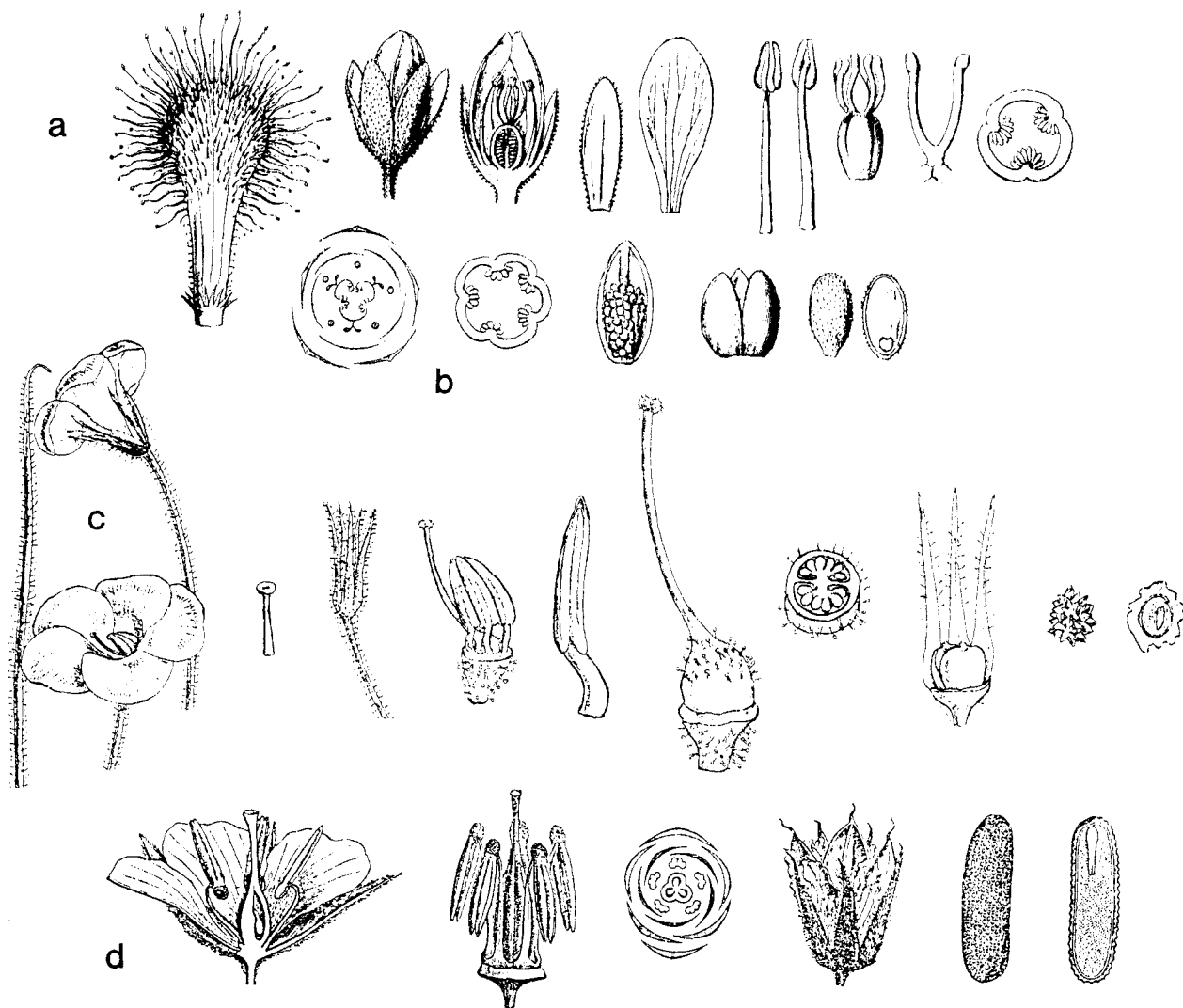


FIGURE 115.—DROSERACEAE: *a*, *Drosera sessilifolia* leaf, *D. intermedia* bud, l.s. of bud, sepal, petal, views of stamen, pistil, branched style, c.s. of ovary; *b*, floral diagram, *D. sessilifolia* c.s. of ovary, single valve of fruit showing the numerous minute seeds, *D. intermedia* dehiscent fruit, seed, l.s. of same showing the minute embryo (after Martius, 1840–1906). BYBLIDACEAE: *c*, *Byblis gigantea* part of leaf and views of flower, glandular hair, calyx, essential organs, stamen, pistil, c.s. of ovary, dehiscent fruit and part of calyx, seed, l.s. of same; *d*, *Roridula dentata* l.s. of flower, essential organs, floral diagram, dehiscent fruit and perianth, seed, l.s. of same (after Hooker and Hooker, 1837–1982; Baillon, 1866–1895).

stigmas apical, sometimes branched; ovary superior, unilocular, rarely 3- or 5-locular, the ovules (3–) numerous, parietal or basal, rarely axile or free-central, bitegmic, crassi- or tenuinucellar, anatropous; fruit a loculicidal capsule or indehiscent (*Aldrovanda*), the seeds spindle-shaped, mi-

nute; embryo straight, subglobular, 0.1–0.3 the length of the endosperm; cotyledons barely differentiated, 0.25 the length of the embryo; endosperm copious, crystalline-granular.

Composition: 4 genera, 100 species.

Distribution: Almost cosmopolitan, in wet

soil, one genus aquatic; centered in Australia and New Zealand; much of Eurasia; tropical and temperate southern Africa; North America; north-eastern half and southwestern tip of South America.

BYBLIDACEAE (Figure 115*c,d*).—Herbs and shrublets; xylem vessel perforation plates simple (*Byblis*) or scalariform with numerous bars (*Roridula*); leaves alternate, linear or lanceolate, entire or pinnatifid, circinnate in vernation, with stalked, capitate, viscous glands, exstipulate; inflorescences few-flowered racemes, or more commonly the flowers solitary, axillary on long or short pedicels; flowers bisexual, actinomorphic; sepals 5, free or basally connate, imbricate; petals 5, free or sometimes very shortly connate, imbricate or contorted; stamens 5, alternipetalous, hypogynous or very shortly adnate to the base of the petals, the filaments short; anthers basifixed, with a swollen rounded base, sometimes didymous, connivent, dehiscent by apical pores or short slits; pollen 3–4-colpate or colpoidate, occasionally 4-rupate or 6-rugate; pistil 1, the carpels 2–3, the style 1, elongate or short, the stigma capitate or very shortly 2–3-lobed; ovary superior, 2–3-locular, the ovules 1–several per locule, axile, sometimes subapical, bitegmic (unitegmic? in *Byblis*), tenuinucellar, anatropous; fruit a loculicidal capsule; embryo minute, globular and undifferentiated, 0.2 the length of the endosperm (*Byblis*) or straight, 0.4–0.6 the length of the endosperm, the cotyledons not broadened, 0.2–0.4 the length of the embryo; endosperm copious, fleshy.

Composition: 2 genera, 4 species.

Distribution: Northern and western Australia, New Guinea; South Africa.

PODOSTEMACEAE (Figure 116*a,b*).—Submerged fresh-water ± thalloid herbs; laticiferous secretory canals and cavities in some; vascular system in the form of a network; leaves alternate, usually simple, linear to lamellate, often basally sheathing; inflorescences terminal, cymose, in fascicles or dichasia, or the flowers solitary; flowers minute, bisexual, fragrant, often enclosed in a spathe, the parts hypogynous; sepals 2, 3, or 5,

sometimes petaloid, free or basally connate; petals 0; stamens 1–25, in 1 or 2 series, the filaments free or connate, the anthers dorsifixed or basifixed, small; pollen grains single or in dyads or tetrads, 3-colpate, 3-colporoidate, oligo-12-forate or nonaperturate; pistil 1, the carpels 2 (3), the styles 2 (1–3), free or partially connate, filiform or short, often strongly papillate, apex punctiform, or capitate when one, the stigmas apical or decurrent; ovary superior, sometimes stipitate, 2(1–3)-locular, the placentas axile, thick, rarely free-central, the ovules numerous, rarely few (2 or 4 in *Farmeria*), bitegmic, tenuinucellar, anatropous; fruit a septicidal or septicifragile capsule or rarely indehiscent (*Farmeria* sp.); seeds minute, the embryo straight, the cotyledons thick, sometimes unequal, the radicle short; endosperm 0.

Composition: 45 genera, ~150 species.

Distribution: Attached to rocky substrate in rushing water, mainly tropical and subtropical, especially America; temperate North America to tropical South America; central Africa, Madagascar; India to Indochina and the East Indies, northern Australia.

HYDROSTACHYACEAE (Figure 116*c,d*).—Submerged fresh-water herbs; vascular bundles in an isolated ring, accompanied by medullary and cortical strands in the inflorescence axis; leaves radical, elongate, simple or pinnatisect, dilated and ligulate basally; inflorescence a dense scapose spike; plants dioecious, rarely monoecious, the flowers sessile in the axil of bracts; perianth 0; stamen 1, the filament short, the anther sacs separate; pollen in tetrads, probably nonaperturate; pistil 1, the carpels 2, the styles 2, long, filiform, free or basally connate, divergent, the apex punctiform; ovary superior, unilocular, the placentas 2, parietal, the ovules numerous, unitegmic, tenuinucellar, anatropous; fruit a septicidal capsule, the seeds numerous, minute; embryo linear, the cotyledons not broadened(?), 0.8–0.9 the length of the embryo; endosperm 0.

Composition: 1 genus, ~20 species.

Distribution: Centered in Madagascar, a few species in tropical and southern Africa.

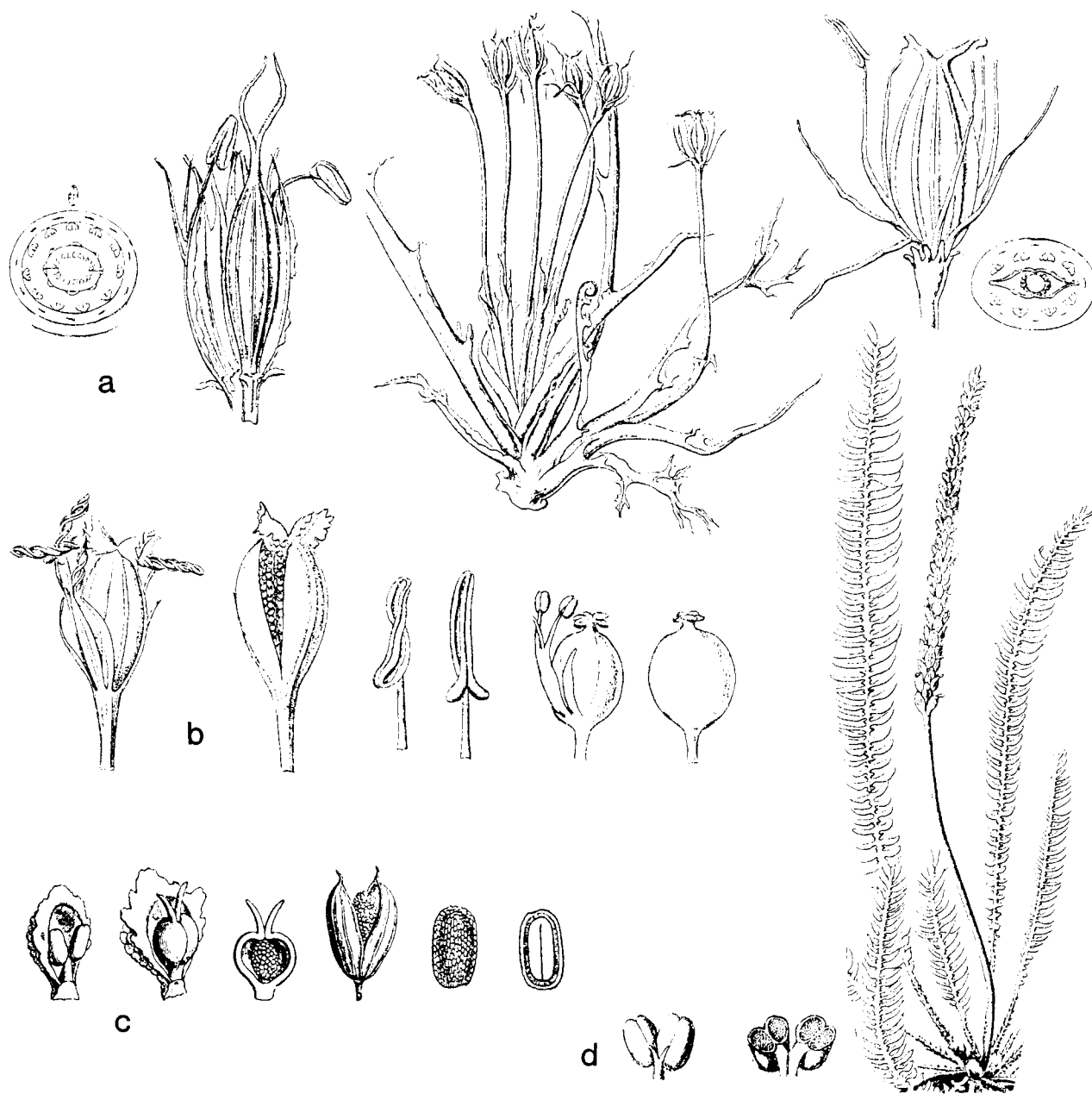


FIGURE 116.—PODOSTEMACEAE: *a*, *Tulasneantha monodelpha* floral diagram, flower, *Rhynchos-laxis linearis* part of plant in flower, immature fruit, floral diagram; *b*, *Lophogyne helicandra* immature fruit, dehiscent fruit, views of anther, *Mniopsis weddelliana* flower, fruit (after Martius). HYDROSTACHYACEAE: *c*, *Hydrostachys verruculosa* ♂ flower, ♀ flower, l.s. of ovary, dehiscent fruit, seed, l.s. of same; *d*, *H. distichophylla* stamen, c.s. of anther, part of plant in flower (after Baillon, 1866–1895; Delessert).

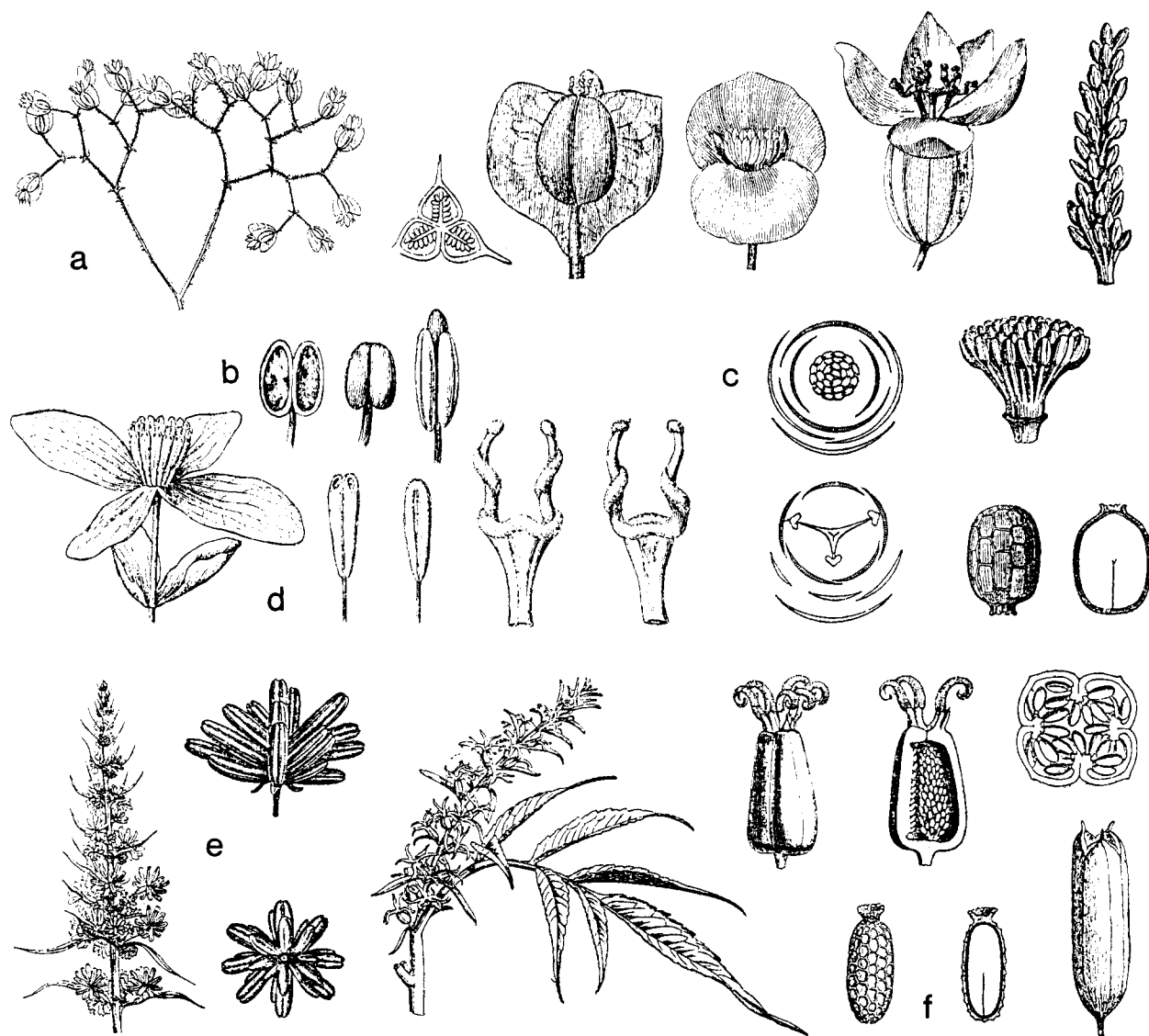


FIGURE 117.—BEGONIACEAE: *a*, *Begonia saxifraga* inflorescence (without the primary peduncle), *B. luxurians* c.s. of fruit, fruit, *B. neglecta* ♂ flower, ♀ flower, *Begonia (Barya)* sp. androecium; *b*, *B. luxurians* 2 views of stamen, *B. hispida* stamen; *c*, *Begonia* sp. diagram of ♂ flower, *B. (Eupetalum)* sp. androecium; *d*, *B. populnea* ♂ flower, views of stamen, views of style and stigma, *Begonia* sp. ♀ floral diagram, seed, l.s. of same (after Martius, 1840–1906; Le Maout and Decaisne, 1873). DATISCEAE: *e*, *Datisca cannabina* ♂ flowering shoot, ♂ flower lateral view and from below, part of ♀ inflorescence, ♀ flower, l.s. of same, c.s. of ovary; *f*, seed, l.s. of same, dehiscent fruit (after Baillon, 1866–1895; Le Maout and Decaisne, 1873).

BEGONIALES

Herbs, often succulent, rarely subshrubs, rarely climbing, the stems sometimes jointed with swollen nodes; xylem vessel perforation plates

simple and scalariform with many bars; leaves alternate, very rarely opposite, usually simple, sometimes compound, usually toothed, stipulate or exstipulate; flowers unisexual, rarely bisexual; sepals 2–6 (–10), usually corolline, usually free,

rarely connate; petals 2–5 or 0; stamens mostly numerous, to ~100, rarely as few as 4, the filaments free or connate; anthers adnate or basifixed, often didymous and the connective produced apically, dehiscent longitudinally, rarely by pores; pollen 3-colporate; pistil 1, the carpels 3 (2–5), styles 3 (2–5), free or basally connate, usually bifid apically, stigmatic for a considerable distance; ovary inferior, rarely semi-inferior, 3 (1–5)-locular, the ovules numerous, axile on lamina, rarely parietal; fruit a capsule dehiscing apically between the styles or loculicidal, rarely a berry, the seeds numerous, minute; embryo straight, terete, endosperm scanty or absent.

Distribution: Pantropical and -subtropical, except Australia, few in temperate regions, in moist or dry habitats.

BEGONIACEAE (Figure 117*a–d*).—Herbs, rarely subshrubs, rarely climbing, mostly succulent, the stems sometimes jointed with swollen nodes; xylem vessel perforation plates simple and scalariform with many bars, both types sometimes in a single vessel; leaves alternate, very rarely opposite (verticillate at the apex of the stem in *Begonia verticillata*), simple or rarely palmately or pinnately compound, mostly asymmetrical, sometimes distichous, sometimes basal, usually toothed, stipulate; plants monoecious; inflorescences often axillary dichasia, tending toward cincinni or sometimes the flower solitary; ♂ flower: sepals 2 or 4 (5), corolline, usually free, rarely connate; petals 5–2 or 0, usually free, rarely connate; stamens mostly numerous (to ~100), rarely as few as 4, the filaments free or connate; anthers adnate or basifixed, the thecas often separate, the connective mostly produced apically, dehiscing longitudinally, rarely by pores; pollen 3-colporate; ♀ flower: sepals 5–2; petals 5–2 or tepals 5–2 (6–8); pistil 1, the carpels 3 (2–5), the styles 3 (2–5), free or connate basally, the apices often twisted and bifid, papillose and stigmatic for a considerable distance; ovary usually completely inferior, rarely semi-inferior (*Hillebrandia*), 3(1–5)-locular, the ovules very numerous, axile or rarely parietal (*Hillebrandia*), bitegmic, crassinucellar or tenuinucellar, anat-

ropous; fruit a capsule dehiscing between styles, or loculicidal, rarely a berry; seeds minute, very numerous, sculptured; embryo straight, the cotyledons not broadened, 0.2–0.5 the length of the embryo; endosperm scanty or 0.

Composition: 3 genera, ~1400 species.

Distribution: Pantropical and -subtropical, except Australia; most frequent in South America.

DATISCAEAE (Figure 117*e,f*).—Herbs; xylem vessel perforation plates simple; leaves alternate, pinnately compound, serrate, exstipulate; inflorescences axillary and terminal fascicles forming a large panicle, the plants usually dioecious, rarely monoecious or the flowers bisexual; calyx lobes in ♂ 4–6 (–10), in ♀ 3 or 6; petals 0; stamens 4–25, the filaments very short, free; anthers large, oblong, basifixed; pollen 3-colporate; pistil 1, the carpels 3–5, the styles 3–5, free, filiform, each bifid, papillose and stigmatic for most of their length; ovary inferior, unilocular, the ovules very numerous, parietal, bitegmic, crassinucellar, anatropous; fruit a capsule dehiscing apically between the styles; seeds minute, numerous; embryo terete, cotyledons 0.5 the length of the embryo; endosperm 0.

Composition: 1 genus, 2 species.

Distribution: Dry habitats; southwestern United States, Mexico; western Mediterranean region to central Asia and the Himalayas.

APIALES

Herbs, shrubs, and trees, rarely climbing, the tissues with secretory canals containing oily, resinous, mucilaginous or gummy material; xylem vessel perforation plates usually simple, but scalariform plates predominant in some genera; leaves alternate, very rarely opposite or whorled, mostly compound, rarely simple, the leaflets toothed, rarely entire, stipulate or exstipulate; inflorescences often umbellate; flowers small, bisexual rarely unisexual; sepals 5 (3–10), connate and usually reduced; petals 5 (3–10, 0), free, rarely connate; stamens 5 (3 to ~100), free, the anthers basifixed or dorsifixed; pollen 3(2–4)-colporate, 3-colpate or 6-rugate; glandular disk

epigynous; pistil 1, the carpels 2 or 5 (1 to ~160), styles 2 or 5 (0 to ~160), free, less commonly connate, the stigmas apical; ovary inferior, very rarely semi-inferior or superior, 2 or 5 (1 to ~160)-locular, the ovules 1 per locule, axile-apical, unitegmic; fruit a schizocarp, drupe or berry; embryo usually minute; endosperm copious.

Distribution: Cosmopolitan in various habitats.

Chemistry: The Araliaceae and Apiaceae are very closely related. Apiaceae have lots of coumarins and monoterpenes (also other terpenes). Saponins are common only in Araliaceae and Apiaceae, but triterpenoid saponins and/or sapogenins are reported from these and Alangiaceae and Cornaceae. Ellagic acid occurs in Cornaceae but not Apiaceae. Kaempferol and caffeic acid occur in all four families. Acetylenic compounds occur mainly in Asteraceae and Apiaceae, but also in Araliaceae, Pittosporaceae, Lauraceae, Myoporaceae, and legumes. Aucubin (iridoid)-type glycosides occur in Cornaceae and Garryaceae but not Araliaceae and Apiaceae. Alkaloids of 9 groups are known from the order but no group occurs in more than one family. Unlike Cornales, *Griselinia* does not have aucubin (iridoid) glycosides. *Griselinia* has triterpinoid saponins and/or sapogenins. Chemical evidence seems to indicate a relationship of Pittosporaceae to Apiales. It has many saponin-containing members.

ARALIACEAE (Figure 118a-c).—Trees and shrubs, less commonly herbs or lianas, the tissues with secretory canals containing oily, resinous, or gummy material; xylem vessel perforation plates usually simple, but scalariform plates predominant in some genera; leaves alternate, very rarely opposite, very rarely whorled (*Panax*), mostly compound, sometimes simple, the leaflets generally toothed, rarely entire, the indument often stellate, stipulate or rarely exstipulate; inflorescences terminal and axillary, often compound, racemes, umbels, heads, spikes or panicles, rarely ending in cymes; flowers bisexual or the plants polygamous or dioecious; sepals 5 (3–10), connate, the calyx truncate or toothed; pet-

als 5 (3–10), valvate or slightly imbricate, free or rarely connate and calyptrate; stamens 5 (3 to ~100), alternipetalous, free; anthers small, about as long as wide, dorsifixed; pollen 3(2–4)-colporate, 3-colpate or 6-rugate; disk epigynous, sometimes lobed; pistil 1, the carpels 5 (1 to ~160), styles 5 (0 to ~160), long or short, free or connate, the stigmas apical; ovary inferior, rarely semi-inferior, very rarely superior (*Tetraplasandra gymnocarpa*), 5(1 to ~160)-locular, the ovules sometimes with an obturator, 1 per locule, axile, unitegmic, crassinucellar or tenuinucellar, anatropous; fruit usually a drupe or berry, rarely a schizocarp (*Myodocarpus*), sometimes with oily vesicles, rarely concrescent into a head (*Meryta*); embryo often minute and undifferentiated, sometimes spatulate, 0.06–0.7 the length of the endosperm; cotyledons to 3 times the width of the radicle, 0.3–0.4 the length of the embryo; endosperm copious, fleshy, sometimes ruminant.

Composition: 60 genera, 700 species.

Distribution: Tropical and subtropical, relatively few temperate; centered in southeast Asia and tropical America.

APIACEAE (Figure 118d).—Herbs, rarely shrubs or small trees, very rarely twining or scandent, the tissues with secretory canals containing resinous, oily, or mucilaginous material; xylem vessel perforation plates usually simple, but occasionally scalariform with few bars; leaves alternate, rarely opposite (*Bowlesia*, *Apiastrum* spp.), basally sheathing, mostly compound, rarely simple, the leaflets mostly toothed, rarely entire, very rarely reduced to a petiole, exstipulate or rarely stipulate; inflorescences axillary, simple or compound, cymose umbels or rarely heads or umbels racemose-paniculate, or the flowers solitary (*Xanthosia*, *Azorella*); flowers bisexual or rarely the plants monoecious or polygamous, rarely dioecious (*Arctopus*); calyx consisting of 5 minute teeth or the latter obsolete, or petaloid; petals 5 (0), free, valvate or slightly imbricate; stamens 5, alternipetalous, free; anthers small, about as long as wide, basifixed or dorsifixed; pollen 3(2)-colporate; disk epigynous; pistil 1, the carpels 2, sometimes 1 aborts (*Echinophora*), an occasional flower is trimerous, the styles 2, free,

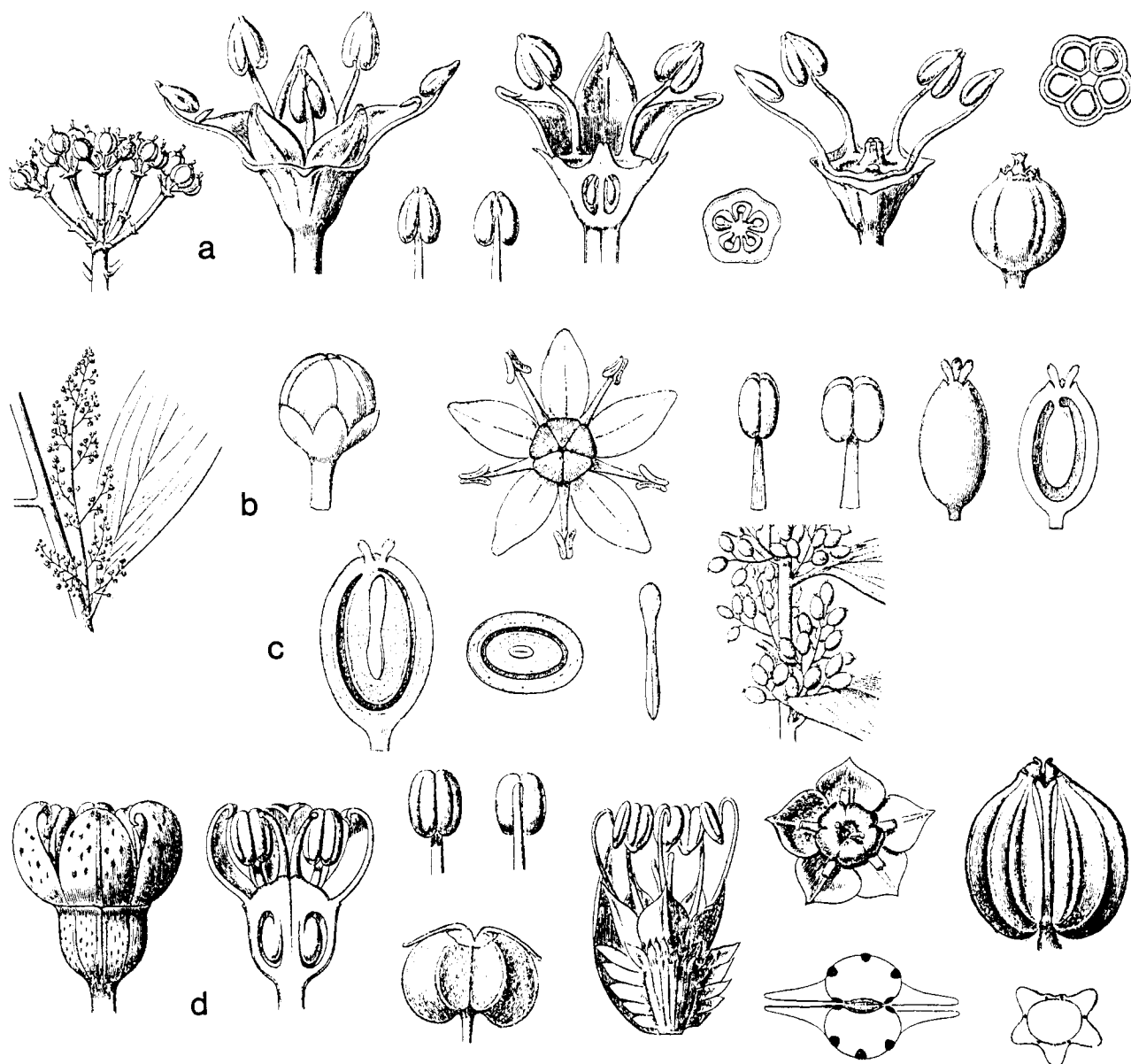


FIGURE 118.—ARALIACEAE: *a*, *Gilibertia resinosa* part of infructescence, flower, views of anther, l.s. of flower, c.s. of ovary, flower with petals and 1 stamen removed, fruit and c.s. of same; *b*, *Griselinia ruscifolia* ♂ inflorescence, ♂ bud, ♂ flower, views of anther, ♀ flower, l.s. of same; *c*, l.s. and c.s. of fruit, embryo, ♀ axillary inflorescences (after Martius, 1840–1906). APIACEAE: *d*, *Hydrocotyle quinqueloba* bud, l.s. of bud, views of stamen and fruit, *Eryngium pristis* flower, same from above with anthers and petals removed and c.s. of fruit, *Apium ammi* fruit and c.s. of mericarp (after Martius, 1840–1906).

stigmas apical; ovary inferior, bilocular, rarely unilocular (*Lagoecia*, *Echinophora*), the ovules 1 per locule, sometimes with an obturator, axile-apical, unitegmic, pseudocrassinucellar or ten-

uinucellar, anatropous; fruit a schizocarp with oily vesicles, sometimes winged, the seeds 2, rarely 1, very rarely the mericarps not separating (*Thecocarpus*); embryo usually minute, sometimes

undifferentiated, 0.03–0.6 the length of the endosperm; cotyledons usually thin, sometimes moderately thick, 1–3 times the width of the radicle, 0.2–0.6 the length of the embryo; endosperm copious, usually firm, fleshy.

Composition: ~300 genera, ~2800 species.

Distribution: Cosmopolitan except part of the arctic region and some deserts; chiefly temperate Northern Hemisphere; Apioideae are bipolar but centered in Eurasia; Saniculoideae are bipolar but better represented in the Southern Hemisphere than the Apioideae; Hydrocotyloideae are predominantly Southern Hemisphere.

CORNALES

Trees and shrubs, very rarely herbs; xylem vessel perforation plates scalariform, usually with many bars, occasionally also simple; leaves opposite or alternate, simple, usually entire, sometimes toothed, exstipulate; flowers small, bisexual, less commonly unisexual; sepals 4–5 (0), free or connate; petals 4–5 (–8, 0), free; stamens 4–5 (1–12) in 1–2 series; staminodes rarely present; filaments usually short, free, the anthers basifixed or dorsifixed; pollen 3-colporate; glandular disk usually present; pistil 1, the carpels 2 (1–10), style 1 (2), rarely lobed, the stigma usually apical, rarely decurrent ventrally; ovary inferior, 2(1–10)-locular, the ovules 1 (2) per locule, axile-apical, unitegmic; fruit a drupe or berry, rarely subsamaroid; embryo straight, minute to as long as the endosperm; endosperm copious or moderate, rarely scanty.

Distribution: Mainly temperate Northern Hemisphere, a few subtropical.

Chemistry: The HCl/Methanol test is positive in Cornaceae, negative in Apiaceae. All Cornaceae have tannin. Garryaceae lack tannin. Tannins are widely distributed in plants, mainly in woody ones. The capacity to synthesize tannin is a primitive character. Garryaceae and Cornaceae have aucubin (iridoid)-type glycosides unknown elsewhere in the order. In most respects the order agrees well with Apiales. Results with leu-

coanthocyanins are different from Apiaceae. Triterpenoid saponins and/or sapogenins are reported to occur in *Cornus*.

DAVIDIACEAE (Figure 119d).—Trees; buds perulate; xylem vessel perforation plates scalariform with very numerous bars; leaves alternate, toothed, exstipulate; inflorescences in axil of uppermost leaf on short spurs, dense globose heads subtended by 2 large white bracts, the plants andromonoecious or polygamous; flowers small, ♂ numerous, perianth 0; stamens 5–6 (1–12), the filaments long, anthers basifixed; pollen 3-colpoidorate; ♀ or bisexual flower solitary, lateral-subterminal, calyx 0 or of minute teeth according to some authors; petals 0; staminodes or stamens with short filaments inserted around the base of the style; disk 0; pistil 1, the carpels 6–10, style 1 with 6–10 linear lobes stigmatic ventrally; ovary 6–10-locular, the ovules 1 per locule, axile-apical, unitegmic, crassinucellar(?), anatropous; fruit a drupe with a stony sulcate endocarp and hard epicarp; seeds usually 1–5, embryo straight, as long as the endosperm, the cotyledons flat, 0.7 the length of the embryo and 2.7 times the width of the radicle; endosperm moderate, fleshy.

Composition: 1 genus, 1 species.

Distribution: Southwestern China.

NYSSACEAE (Figure 119a–c).—Trees and shrubs; xylem vessel perforation plates scalariform with many bars, usually more than 20; leaves alternate, simple, entire or few-toothed, exstipulate; inflorescences terminal or axillary, umbels, racemes, heads, or rarely the flowers solitary; flowers small, bisexual or the plants polygamodioecious; sepals 5; petals 5 (4–8), free, imbricate, or 0; stamens 8–10, often in 2 series, the filaments short; anthers small, dorsifixed, dehiscing longitudinally; pollen 3-colporate; disk pulvinate, epigynous in ♀, central in ♂; pistil 1, the carpels 1–2, style 1 (*Nyssa*), or bifid (*Campotheca*), the stigma(s) decurrent; ovary inferior, 1–2-locular, the ovules 1 per locule, apical, unitegmic, crassinucellar(?), anatropous; fruit a drupe or subsamaroid, the seed 1; embryo straight, as long as the endosperm, the cotyledons moderately thin, 4.7 times wider than the radicle,

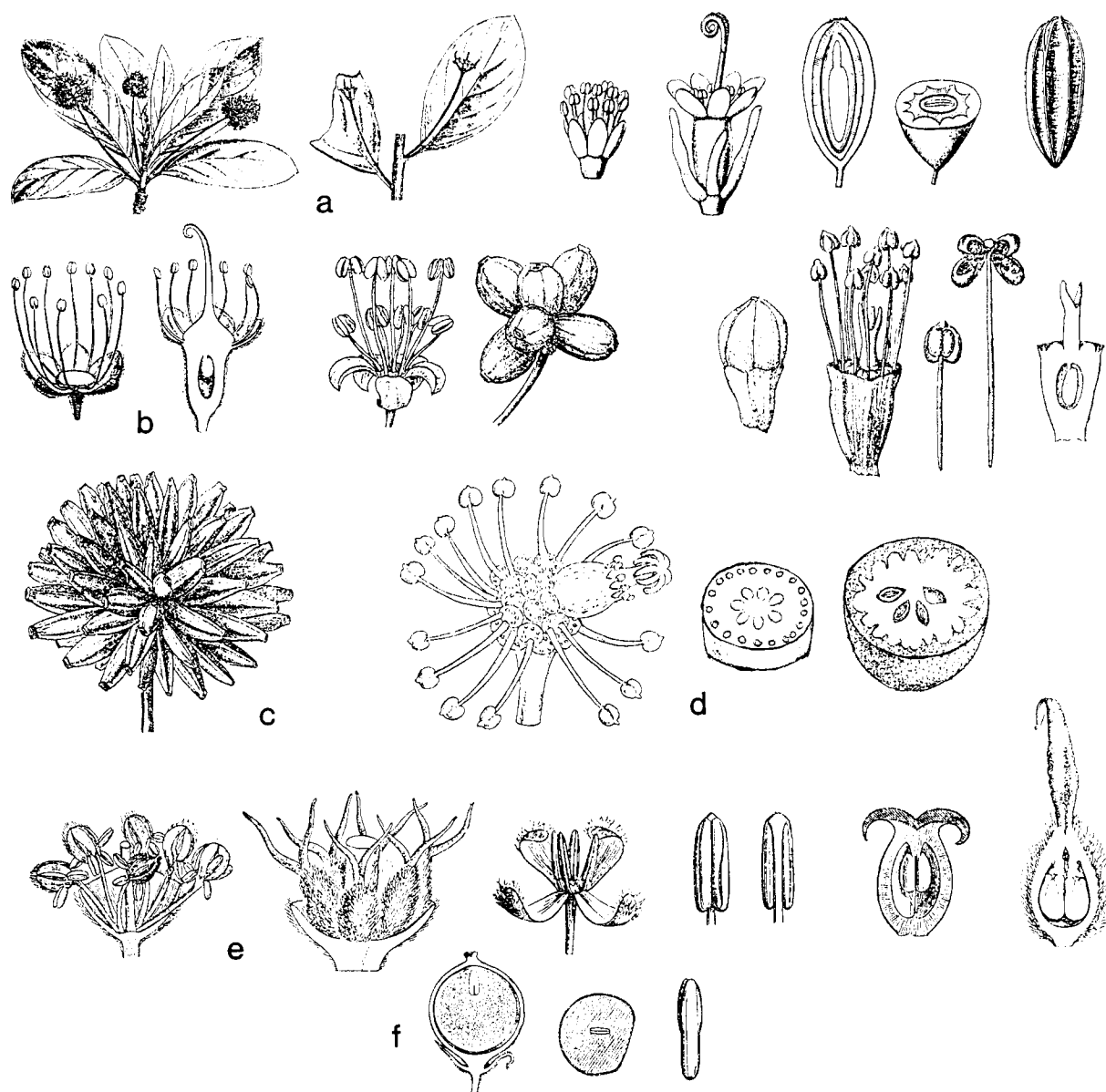


FIGURE 119.—NYSSACEAE: *a*, *Nyssa sylvatica* twig with ♂ inflorescences, twig with ♀ inflorescences, *N. aquatica* ♂ flower, ♀ flower, l.s. and c.s. of fruit, putamen; *b*, *N. biflora* ♂ flower, l.s. of bisexual flower, *N. javanica* ♂ flower, infructescence, *Camptotheca acuminata* bud, flower (the petals fallen), stamen before and after dehiscence, l.s. of ovary; *c*, infructescence (after Wangerin; Sargent; Baillon, 1866–1895). DAVIDIACEAE: *d*, *Davidia involucre* inflorescence (most of the stamens fallen), c.s. of ovary, c.s. of fruit (after Oliver, Hemsley). GARRYACEAE: *e*, *Garrya elliptica* part of ♂ inflorescence, part of ♀ inflorescence, ♂ flower, views of anther, l.s. of ovary, *G. fadyenii* l.s. of ovary; *f*, *G. laurifolia* l.s. of fruit, *G. elliptica* c.s. of seed, embryo (after Baillon, 1866–1895; Le Maout and Decaisne, 1873).

0.7 the length of the embryo?; endosperm scanty or copious.

Composition: 2 genera, 9 species.

Distribution: Temperate and subtropical; eastern North America; eastern Asia from temperate China and Japan to western Malaysia and the Himalayas.

GARRYACEAE (Figure 119*e,f*).—Trees and shrubs; xylem vessel perforation plates scalariform with few bars; leaves opposite, simple, entire, exstipulate; plants dioecious; inflorescences catkin-like racemes or spikes; ♂ flower: sepals 4, valvate, free; petals 0; stamens 4, alternisepalous, free, the filaments short; anthers elongated, basifixed, the connective produced apically; pollen 3-colporate, the colpi rather short, narrow; ♀ flowers: sepals 0 or 2–4, minute; petals 0; disk 0 or very imperfect; pistil 1, the carpels 2 (3), styles 2, the stigmas decurrent; ovary inferior, unilocular, the ovules 2, apical, with an obturator, unitegmic, the integument very massive, crassinucellar, anatropous, the funicle rather long; fruit 1–2-seeded, the testa thick, fleshy; embryo minute, straight, 0.3 the length of the endosperm, the cotyledons 1.1 times wider than the radicle, 0.5 the length of the embryo; endosperm copious, firm to hard.

Composition: 1 genus, 15 species.

Distribution: Dry habitats; western United States to Panama; West Indies.

CORNACEAE (Figure 120*a*).—Trees, shrubs, or rarely herbs; xylem vessel perforation plates mostly scalariform with many bars, occasionally also simple; leaves opposite, rarely alternate, simple, mostly entire, rarely toothed, exstipulate; inflorescences terminal or axillary, corymbose, racemes, heads, umbels, rarely panicles, sometimes dichasia or pleiochasia; flowers small, bisexual or rarely the plants monoecious, polygamodioecious or dioecious; calyx minute, 4–5-lobed; petals 4–5, free, valvate; stamens 4–5, alternipetalous, the filaments rather short, free; anthers small, about as long as wide, dehiscing longitudinally, basifixed or dorsifixed; pollen usually 3-colporate; disk epigynous, surrounding the base of the style, central in ♂ flowers; pistil 1, the

carpels 2 (–4), style 1, the stigma short, apical, subcapitate; ovary inferior 2(1–4)-locular, the ovules 1 per locule, apical, unitegmic, usually crassinucellar, sometimes tenuinucellar, anatropous; fruit a drupe or berry, the seeds 4–1; embryo straight, 0.3–0.9 the length of the endosperm; cotyledons thin, 2–3.3 times wider than the radicle, 0.4–0.7 the length of the embryo; endosperm copious or moderate, fleshy.

Composition: 12 genera, 100 species.

Distribution: Mainly temperate Northern Hemisphere, some species in the tropics and subtropics.

DIPSACALES

Herbs, shrubs, and small trees, rarely climbing; xylem vessel perforation plates simple, less commonly scalariform, rarely with more than 20 bars; leaves opposite, simple or sometimes compound, sometimes lobed or divided, entire or toothed, exstipulate, very rarely stipulate; flowers bisexual, rarely unisexual, often zygomorphic, sometimes involucrate; sepals 5–4 (1–3), connate, the calyx minute, sometimes papus-like or plumose in fruit; petals 5–4 (3, 6), connate, the corolla sometimes gibbous or spurred; stamens 5–4 (1–6), equal or sometimes didynamous, inserted on the corolla, the filaments free or rarely connate in pairs, anthers dorsifixed or basifixed; pollen 3(4)-colporate or -colporoidate, 3(2–6)-colpate, rarely 4-rupate; pistil 1, the carpels 2–3 (–8), style 1 (–several), the stigma(s) apical; ovary inferior, the locules 1–3 (–8), ovules 1(–several) per locule, unitegmic, tenuinucellar, rarely crassinucellar; fruit a berry, drupe, achene, nutlet, rarely capsule; embryo straight, minute to nearly as long as the endosperm; endosperm copious to absent.

Distribution: Nearly cosmopolitan, centered in temperate Northern Hemisphere, extending in the mountains of the tropics to temperate Southern Hemisphere.

Chemistry: Gibbs considers that chemistry supports a close relation among the families of this order. In serodiagnostic tests *Adoxa* is said to

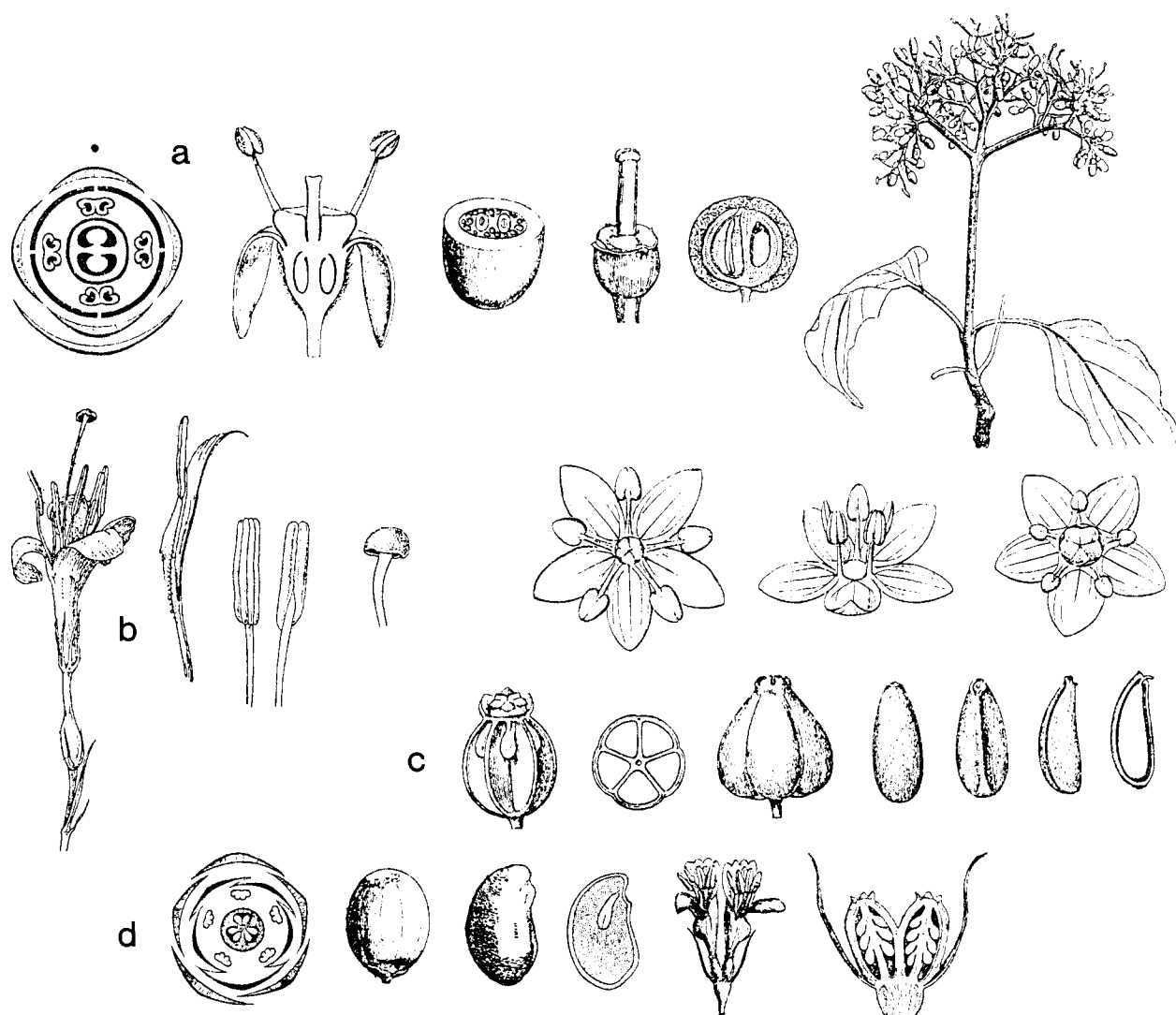


FIGURE 120.—CORNACEAE: *a*, *Cornus mas* floral diagram, l.s. of flower, c.s. of fruit, *C. sanguinea* pistil and calyx, l.s. of fruit, flowering twig (after Baillon, 1866–1895; Le Maout and Decaisne, 1873). CAPRIFOLIACEAE: *b*, *Diervilla lonicera* flower, part of corolla showing insertion of stamen, views of anther, stigma, *Sambucus australis* ♂ flower, corolla and stamens of same, ♀ flower; *c*, pistil with carpels opened showing the ovules, c.s. of ovary, fruit, 3 views of mericarp, l.s. of same showing seed; *d*, *Lonicera caprifolium* floral diagram, fruit, seed, l.s. of same, *L. xylosteum* pair of flowers, *L. ciliata* l.s. of 2 united fruits (after Johnson; Baillon, 1866–1895; Martius, 1840–1906).

react strongly with representatives of Caprifoliaceae, Rubiaceae, and Dipsacaceae, but not Saxifragaceae. In this order sesquiterpenoids seem to occur only in Valerianaceae. *Sambucus* and *Viburnum* are set off chemically from the rest of the Caprifoliaceae.

CAPRIFOLIACEAE (Figure 120*b–d*).—Shrubs and small trees, rarely herbs, sometimes climbing; xylem vessel perforation plates simple, also scalariform, or exclusively scalariform with more than 20 bars (*Diervilla*, *Viburnum*); leaves opposite, simple, entire or toothed, rarely lobed or

deeply divided, sometimes pinnately compound (*Sambucus*), exstipulate or rarely stipulate; inflorescences cymose, a dichasium lacking the middle flower or monochasium; flowers bisexual, actinomorphic or zygomorphic; sepals 5 (4), connate, the calyx small; petals 5 (4), connate, the lobes imbricate in bud, the corolla sometimes gibbous; stamens 5 (4), 2 in *Carlemannia*, *Silvianthus*, inserted on the corolla, rarely didynamous; anthers dorsifixed or basifixed; pollen usually 3-colporate or 3-colporoidate; pistil 1, the carpels 3 (2–8), style 1 (–several), elongated or very short, the stigma(s) 1–5, apical; ovary inferior, the locules 1–3 (–8), the ovules 1 (–several) per locule, axile, unitegmic, usually tenuinucellar, sometimes crassinucellar (*Viburnum*), anatropous; fruit a berry, drupe, achene, or capsule; seeds often with a bony testa; embryo minute or small, straight, 0.1–0.35 (0.75–0.9 in *Sambucus*) the length of the endosperm; cotyledons 1–2 times the width of the radicle, 0.25–0.5 the length of the embryo; endosperm copious, fleshy.

Composition: 13 genera, 450 species.

Distribution: Centered in temperate eastern North America and eastern Asia; almost all Eurasia; cool temperate North America to temperate South America, in the mountains in the tropics; eastern Australia, New Guinea, New Zealand; only present in a small area of northwestern and eastern Africa.

VALERIANACEAE (Figure 121a).—Herbs, rarely shrubs or lianas, dried specimens usually malodorous; xylem vessel perforation plates simple, rarely also some scalariform (*Centranthus ruber*); leaves opposite, sometimes rosulate, often much divided, exstipulate; inflorescence mostly a thyse, sometimes a head; flowers usually zygomorphic, bisexual or the plants rarely dioecious; sepals 5 (2–4 or merely a ring), connate, the calyx minute, but sometimes plumose in fruit; petals 5 (–3), connate, the lobes imbricate, the corolla often saccate or spurred, rarely bilabiate (*Centranthus*); stamens 4–1, inserted on the corolla, the filaments long or the anthers sessile, dorsifixed; pollen 3(4)-colporoidate; pistil 1, the carpels 3, style 1, elongated, the stigmas 1–3,

apical; ovary inferior, 3–1-locular, the ovule 1, axile-subapical, unitegmic, tenuinucellar, anatropous; fruit an achene or nutlet; embryo straight, the cotyledons moderately thick, flattened, 0.7–0.9 the length of the embryo, 3 times as wide as the radicle; endosperm 0.

Composition: 13 genera, 400 species.

Distribution: Centered in temperate Eurasia and the mountains of South America; almost all Eurasia except the southeast; most of temperate America, only a small area of northern and southern Africa and the East Indies; absent from Australia.

ADOXACEAE (Figure 121b,c).—Herbs; xylem vessel perforation plates simple; leaves opposite, some radical, compound, the leaflets toothed, the scale leaves on the rhizome alternate; inflorescence a terminal dichasial cyme, capitate; flowers bisexual, actinomorphic, the lateral ones weakly zygomorphic, with musky smell; sepals 2–3 (1–5), connate; petals 5 (4–6), connate, the corolla rotate; stamens 5 (4–6), inserted on the corolla, the anthers and filaments bifid; pollen 3-colporoidate; disk 0; pistil 1, the carpels 3–5 (2), styles 3–5, the stigmas apical, capitate; ovary semi-inferior, the locules 3–5, ovules 1 per locule, axile-subapical, unitegmic, tenuinucellar, anatropous; fruit a drupe with 1–5 pyrenes; embryo minute, 0.1–0.3 the length of the endosperm; cotyledons not broadened, 0.3–0.4 the length of the embryo; endosperm copious, hard.

Composition: 1 genus, 2 species.

Distribution: Temperate Northern Hemisphere, especially cool, moist regions.

DIPSACACEAE (Figure 121d).—Herbs, rarely subshrubs (*Scabiosa* spp.); xylem vessel perforation plates simple, rarely also scalariform; leaves opposite or rarely verticillate, simple, pinnately dissected, sometimes toothed or with a prickly margin, rarely entire, exstipulate; inflorescences often cymose heads, sometimes subspicate, rarely in verticillasters (*Morina*), usually involucrate; flowers bisexual, mostly zygomorphic, an involucre present; sepals 5–4, small, connate, sometimes divided into segments like a pappus; petals 5–4, connate, the lobes imbricate in bud; stamens

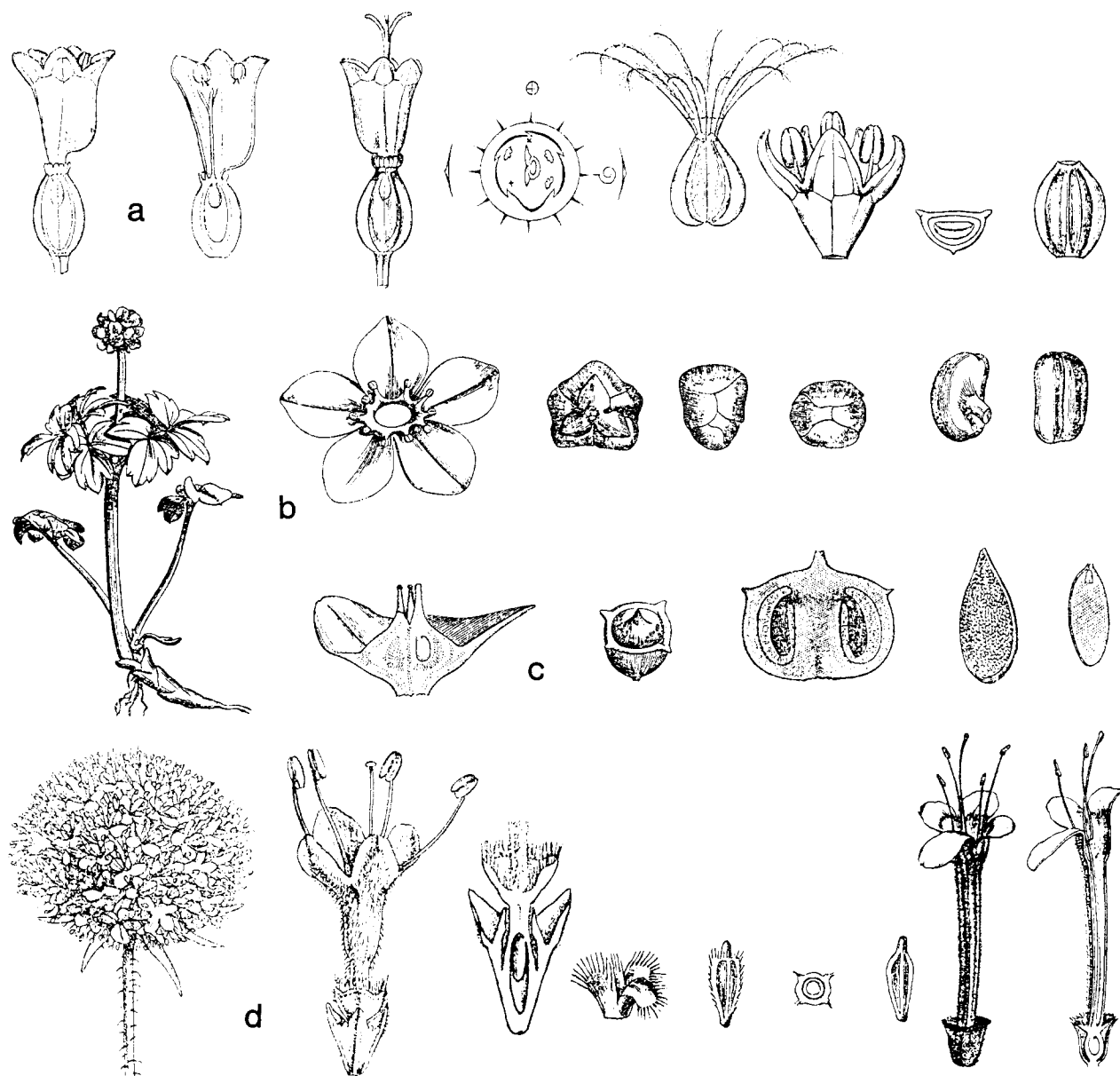


FIGURE 121.—VALERIANACEAE: *a*, *Valeriana scandens* ♂ flower, l.s. of flower, ♀ flower, floral diagram, fruit, *V. gilgiana* corolla and stamens, c.s. of fruit, *V. eichleriana* fruit (after Martius, 1840–1906). ADOXACEAE: *b*, *Adoxa moschatellina* plant in flower, corolla and stamens of 5-merous flower, bud from below, 5-merous and 4-merous buds, views of half anther; *c*, l.s. of ovary, fruit and calyx, l.s. of fruit, seed, l.s. of same showing the minute embryo (after Le Maout and Decaisne, 1873). DIPSACACEAE: *d*, *Dipsacus asper* inflorescence, flower, l.s. of ovary with calyx and involucrel, calyx, achene invested by involucrel, c.s. of same, achene, *D. fullonum* flower, l.s. of same (after Oliver, Lecomte).

4 (2–3), equal or sometimes didynamous, inserted on the corolla, the filaments free or united in pairs; anthers dorsifixed; pollen 3(2–6)-colpate, 4-rupate, colpate (*Morina*), or porate; pistil 1, the carpels 2, style 1, elongated, the stigma(s) 1–2, capitate; ovary inferior, unilocular, the ovule 1, axile-subapical, unitegmic, tenuinucellar, anatropous; sometimes there is an increase in the number of antipodal nuclei in the embryo sac; fruit an achene or nutlet; embryo straight, 0.9 (0.3 in *Morina*) to as long as the endosperm; cotyledons moderately or markedly thick, 1.7–4.0 times wider than the radicle, 0.35–0.9 the length of the embryo; endosperm usually scanty, sometimes moderate, fleshy.

Composition: 10 genera, ~250 species.

Distribution: Centered in the Mediterranean region and Near East; temperate Eurasia and India; northern, eastern, southern, and a small part of western Africa.

RUTALES

Trees and shrubs, less commonly herbs, rarely climbing, the bark often bitter; xylem vessel perforation plates simple, rarely also scalariform, very rarely with more than 20 bars; secretory canals, cavities or cells containing aromatic oil or resin often present; leaves alternate, less commonly opposite, usually pinnately compound, rarely simple, the rachis sometimes winged, the leaflets entire or toothed, sometimes gland-dotted, exstipulate, rarely stipulate; flowers small, often abundant, bisexual or unisexual; sepals 5–3 (–8, 0), free or shortly connate; petals 5–3 (–14, 0), free or rarely connate, rarely adnate to a staminal tube; stamens 3–10 (2 to ~100), usually in 1–2 series; staminodes rarely present; filaments free, less commonly connate, rarely inserted on the corolla, sometimes with a basal ligular scale; anthers dorsifixed or basifixed, occasionally apiculate; pollen 3(2–8)-colpate, less frequently ruplicate, poroid or rugoid; glandular disk usually surrounding the base of the ovary; pistils 1 (–6), the carpels 2–5 (1–20), styles 1–5 (0–12), sometimes basal, stigmas apical, very

rarely ventral; ovary superior, very rarely semi-inferior or inferior, 1–5(–20)-locular, the ovules 1–2 (–several) per locule, axile, less commonly basal or subapical, very rarely parietal; fruit a berry, drupe, drupelets, capsule, cocci or samara, the seeds sometimes winged; embryo straight, arcuate, folded or convolute, usually as long as the endosperm; endosperm copious to absent.

Distribution: Mostly pantropical and -subtropical, extending into warm temperate regions, in various habitats.

Chemistry: Many triterpenes occur in the order. The Rutaceae have many monoterpenes in many genera, and several sesquiterpenes occur in several genera. Citrus oil terpenes inhibit some insects. Burseraceae and Meliaceae also have various terpenes. The Rutaceae stand out from the rest of the order as a maker of coumarins and alkaloids (of at least 10 groups). Otherwise the order is not alkaloid-rich. Rutaceae have some lignans. Chromones in *Spathelia* (Rutaceae) and *Neochamaelea* (Cneoraceae) may be indicative of relationship of their families. Degraded triterpenes with a seco-ring A are commonly found in Rutaceae. The only other family with these compounds is Meliaceae. Mangiferin occurs in Anacardiaceae and Melianthaceae (*Bersama*).

RUTACEAE (Figure 122a–d).—Trees and shrubs, rarely herbs, the bark sometimes bitter; xylem vessel perforation plates simple, rarely also a few scalariform plates, rarely some multiperforate plates in a few species; aromatic oil or resin secreting cavities or cells nearly always present in the tissues; leaves alternate or opposite, very rarely verticillate, compound or simple, the rachis sometimes winged, entire or toothed, mostly with pellucid dots, exstipulate; inflorescences terminal or axillary, usually cymose, sometimes racemes, rarely a spike or head, rarely epiphyllous (*Erythrochiton*); flowers bisexual, rarely the plants polygamo-dioecious (*Zanthoxylum*), dioecious (*Skimmia*) or monoecious (*Empleurum*); sepals 4–5 (0, 3), free or basally connate; petals 4–5 (0, 3), free or rarely connate; stamens 4–10 (2), rarely more (50–100 in *Clymenia*), obdiplostemonous or rarely diplostemon-

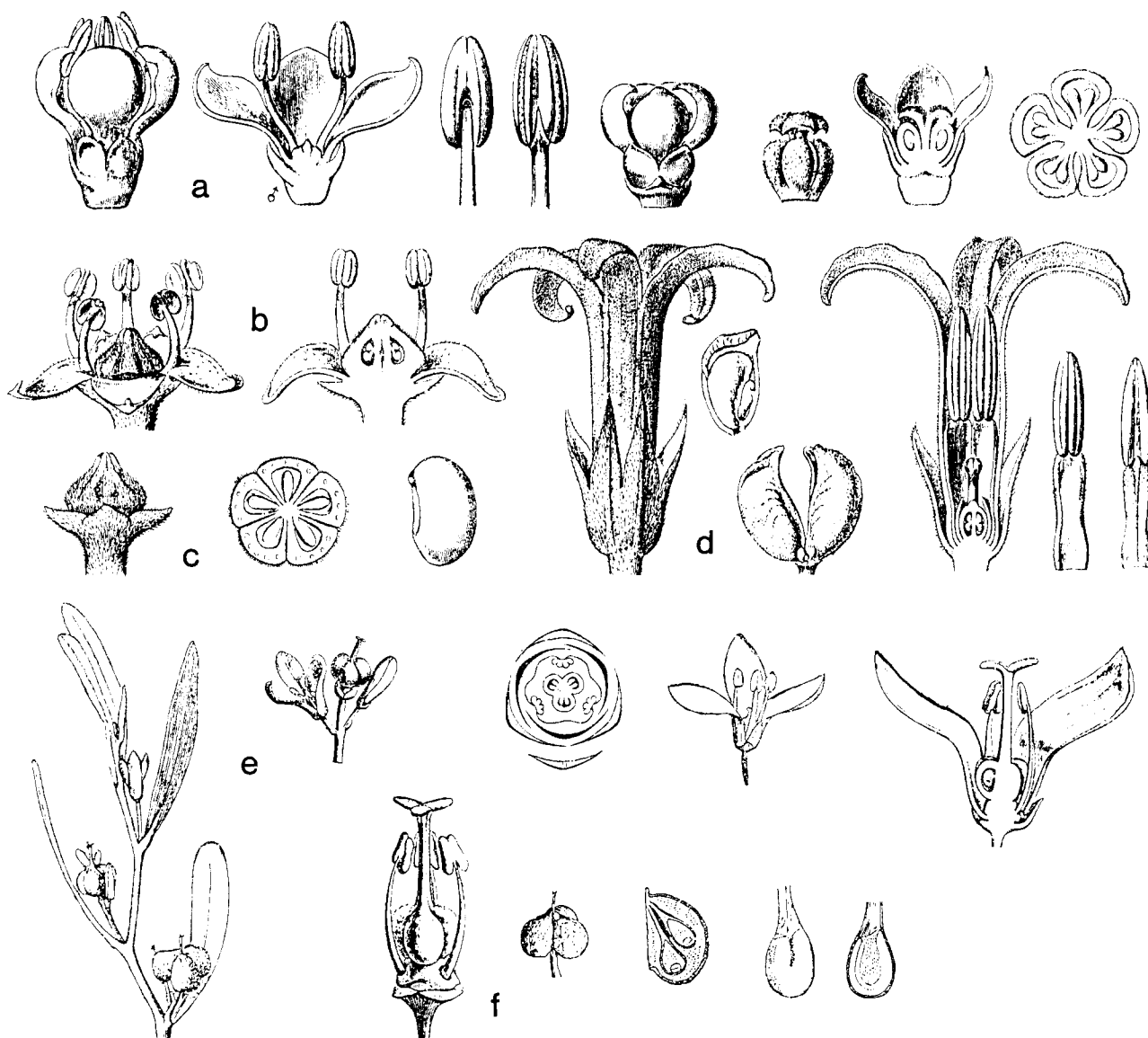


FIGURE 122.—RUTACEAE: *a*, *Zanthoxylum chiloperone* ♂ flower, l.s. of same, views of stamen, ♀ flower, pistil, l.s. of ♀ flower, c.s. of ovary; *b*, *Pilocarpus macrocarpus* flower, l.s. of same; *c*, pistil and calyx, *P. grandiflorus* c.s. of ovary, *P. macrocarpus* seed; *d*, *Angostura odoratissima* flower, l.s. of mericarp, fruit, l.s. of flower, views of stamen (after Martius, 1840–1906). CNEORACEAE: *e*, *Cneorum tricoccum* flowering and fruiting shoot, part of same, floral diagram, flower, l.s. of same; *f*, essential organs, fruit, l.s. of a fruiting carpel, seed, l.s. of same (after Baillon, 1866–1895; Le Maout and Decaisne, 1873).

ous, or in several series, the filaments free, rarely connate or inserted on the base of the corolla, sometimes with bifid pubescent scales basally (*Dictyoloma*); anthers about as long as wide, the connective sometimes apiculate, sometimes api-

cally glandular; pollen 3(2–8)-colporate; disk usually present below the ovary, or adnate to the calyx tube; gynophore sometimes present; pistils 1–5, sometimes the styles connate and ovaries free, carpels 2–5 (1–16; *Clymenia* 16), the styles

1–5, free or connate, often basal, stigma(s) apical; ovary superior, rarely semi-inferior or inferior, 2–5(1–16)-locular, the ovules 1–several per locule, axile or very rarely parietal (*Feronia*), bitegmic, crassinucellar, anatropous or semi-anatropous; fruit a berry, drupe or rarely 1–4 drupelets, a loculicidal or rarely septicidal capsule, or cocci, rarely a samara, sometimes the endocarp separates from the epicarp; embryo straight or arcuate; linear, or the radicle invested, 0.9–1.0 times the length of the endosperm; cotyledons thin or thick, 1–4 times the width of the radicle, 0.4–0.9 the length of the embryo; endosperm copious to 0, fleshy.

Composition: 150 genera, ~1000 species.

Distribution: Mostly pantropical, extending into warm temperate regions; centered in Australia and South Africa; United States to Argentina; southern Eurasia to Australia and New Zealand; Africa and Madagascar.

CNEORACEAE (Figure 122*e,f*). Shrublets with oil cells in the bark; xylem vessel perforation plates simple; leaves alternate, simple, entire, with secretory cells containing oil or resin, exstipulate; inflorescences adnate to the petiole, cymes, corymbs or the flowers solitary; flowers bisexual, the parts hypogynous; sepals 3 (–4), shortly connate; petals 3 (–4), free; stamens 3(–4), free, the filaments elongated; anthers dorsifixed, about as long as wide; pollen 3(4–6)-colporate; receptacle elongated, disk present; pistil 1, sometimes with septal glands, the carpels 3 (–4), style 1, usually elongated, 3(–4)-lobed and stigmas apical; ovary 3(–4)-locular, the ovules bitegmic, campylotropous or amphitropous, 2 per locule, axile; fruit 1–4 drupaceous cocci; seed arcuate, the embryo arcuate, peripheral, 1–2 times the length of the endosperm; cotyledons not broadened, 0.5–0.7 the length of the embryo; endosperm moderate or copious, fleshy.

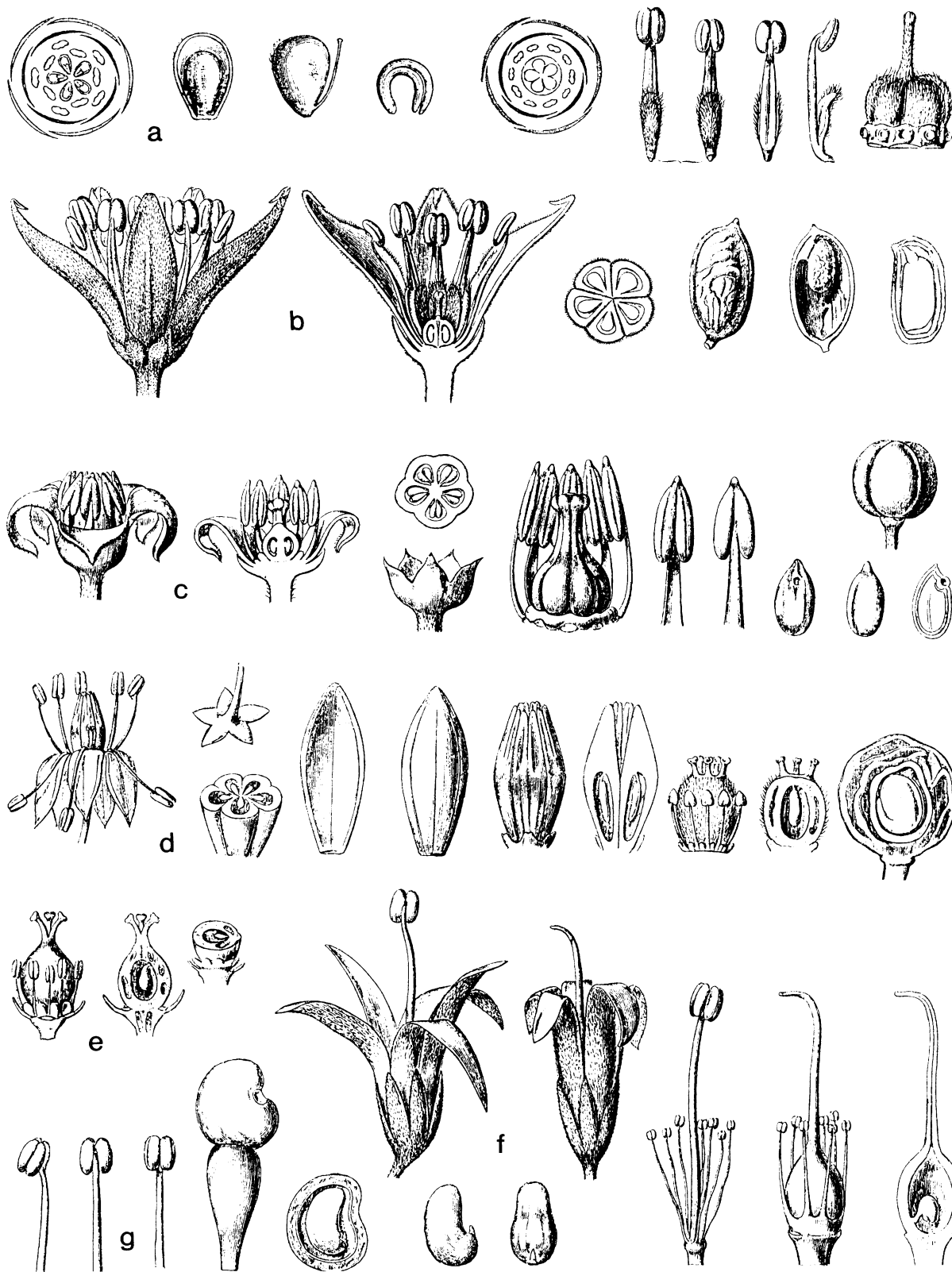
Composition: 2 genera, 3 species.

Distribution: Western Mediterranean region, Canary Islands; Cuba.

SIMAROUBACEAE (Figure 123*a,b*).—Trees and shrubs, usually very bitter; xylem vessel perforation plates exclusively simple, except for occa-

sional multiple perforations in *Ailanthus*; secretory canals in some genera, secretory cells containing oil, resin, or mucilage are less common; leaves alternate, or rarely opposite or absent, compound or rarely simple, the leaflets entire or toothed, never gland-dotted, but some glandular teeth in *Ailanthus*, exstipulate or rarely stipulate; axillary and terminal panicles, racemes or cymose spikes; flowers rarely bisexual, the plants usually dioecious or polygamous, the parts hypogynous; sepals 3–5 (–8 in *Holacantha*), connate, rarely free; petals 3–5 (7–8 in *Holacantha*), free, rarely connate or 0; stamens 3–10, rarely more (12–18 in *Castela*, *Quassia* sp.), mostly obdiplostemonous, rarely opposite the petals when equal to them in number, the filaments long, filiform, free, often with a basal ligular scale, sometimes 5 staminodes present; anthers oblong, dorsifixed; pollen mostly 3-colporate, also 3-colporoidate, 3-colpate(?); disk under the ovary annular or cupular; gynophore sometimes present; pistils 1–5, the carpels (1) 2–5 (8 in *Castela*), often the ovaries free and the styles or stigmas connate; styles 1–5, often basal, the stigmas apical, and sometimes ventral (*Castela*); ovary 1–5-locular, the ovules 1 (2–several) per locule, axile, bitegmic, crassinucellar, anatropous, amphitropous or semi-anatropous; fruit drupelets or drupe, schizocarp, capsule or fruitlets samaras; embryo straight or arcuate, as long as the endosperm; cotyledons thin or thick, 3–5.8 times wider than the radicle, 0.8–

FIGURE 123.—SIMAROUBACEAE: *a*, *Suriana maritima* floral diagram, l.s. of pistil, pistil with basilar style, embryo, *Quassia* sp. floral diagram, *Q. nigrescens* views of stamen, pistil; *b*, flower, l.s. of same, c.s. of ovary, fruit, l.s. of same, l.s. of seed (after Le Maout and Decaisne, 1873; Martius, 1840–1906). BURSERACEAE: *c*, *Protium brasiliense* flower, l.s. of same, c.s. of ovary and calyx, pistil and some of the stamens, views of stamen, views of seed, l.s. of same, fruit (above) (after Martius, 1840–1906). ANACARDIACEAE: *d*, *Spondias macrocarpa* flower, calyx and c.s. of ovary, views of petal, pistil, l.s. of same, *Tapirira marchandii* essential organs, l.s. of pistil, l.s. of fruit; *e*, *Schinus lentiscifolius* essential organs, l.s. and c.s. of ovary; *f*, *Anacardium pumilum* ♂ flower, ♀ flower; *g*, views of stamen, fruit and pedicel, l.s. of fruit, views of embryo, androecium of ♂ flower, essential organs, l.s. of pistil (after Martius, 1840–1906).



0.9 the length of the embryo, embryo not divided in *Aeschrion*; endosperm moderate, scanty or 0, fleshy.

Composition: 20 genera, 120 species.

Distribution: Pantropical and -subtropical, extending into warm temperate regions in Japan and Korea.

BURSERACEAE (Figure 123*c*).—Trees and shrubs with resin or aromatic oil in lysigenous or schizogenous canals; xylem vessel perforation plates simple; leaves alternate, rarely opposite, pinnately compound or decompound, the rachis often winged, rarely simple (1-foliolate), toothed, usually not punctate, exstipulate; inflorescences terminal or axillary racemes or panicles; flowers bisexual or the plants polygamodioecious, minute, the parts hypogynous, rarely perigynous; sepals 3–5, basally connate; petals 3–5 (0), free or rarely connate; stamens 3–10, in 1–2 series, obdiplostemonous, the filaments free (connate in *Canarium* spp.); anthers slightly longer than wide; pollen 3-colporate, rarely 3-colporoidate; disk surrounding base of ovary as in Rutaceae; pistil 1, the carpels 2–5, the style 1, short, stigma usually 2–5-lobed, apical; ovary superior, 2–5-locular, the ovules 2 (1) per locule, axile, 2(1?)-tegmic, crassinucellar, semi-anatropous or campylotropous; fruit a berry or drupe, sometimes a tardily dehiscent capsule; embryo usually folded or convolute, rarely straight; cotyledons thin, or thick and plano-convex, 12–15 times wider than the radicle, 0.7–0.9 the length of the embryo, the radicle sometimes invested; endosperm 0.

Composition: 18 genera, 550 species.

Distribution: Pantropical in a variety of habitats from rain forest to desert and mangrove; best represented in tropical America and northeastern Africa.

ANACARDIACEAE (Figures 123*d–g*, 124*a–e*).—Trees and shrubs, rarely climbers, often with resin-canals in the phloem; xylem vessel perforation plates exclusively simple in most genera, a few scalariform plates in some species, fewer than 20 bars except in one genus; leaves alternate, very rarely opposite, compound, the rachis sometimes winged, or simple, often toothed, exstipu-

late, very rarely obscurely stipulate; inflorescences terminal or axillary panicles or thyrses; flowers bisexual or the plants polygamodioecious or dioecious, the parts hypogynous, rarely perigynous or epigynous; sepals 5 (3–7), free or connate; petals 5 (0, 3–7), free or rarely basally connate; stamens 5 (3 to ~15), the filaments elongated, free or rarely connate basally (*Anacardium*), sometimes all but one staminodal; anthers about as long as wide or slightly longer than wide, dorsifixed, rarely basifixed (*Buchanania*), occasionally apiculate; pollen (2) 3-colporate, less frequently 4-ruporate or 3–8?-poroid, colpoid, rugoid or foraminoid; disk usually present around the base of the ovary; gynophore rarely present; pistils 1 (4–6), the carpels 1–3 (5–12 *Pleiogynium*), the styles 1 (5–12), often distant, rarely basal, the stigmas apical; ovary unilocular (2–12), usually superior, rarely inferior, the ovules 1 per pistil or carpel, axile, basal or subapical, 1–2-tegmic, crassinucellar, anatropous, the funicle often long; fruit mostly a drupe; embryo bent or arcuate, 1.5–1.8 times longer than the endosperm; cotyledons thin or moderately thick, 4.5–6.5 times wider than the radicle, 0.6–0.9 the length of the embryo; endosperm scanty or 0, fleshy.

Composition: 70 genera, 600 species.

Distribution: Pantropical, extending into temperate America, Africa and Eurasia; equally well represented in South America, Africa, and Malaysia.

MELIACEAE (Figure 125*a,b*).—Trees and shrubs, very rarely subshrubs, with secretory cavities in the cortex and pith of a few genera, sometimes bitter, wood scented; xylem vessel perforation plates simple; leaves alternate, rarely opposite, mostly pinnately compound or decompound, the leaflets entire or toothed, more rarely simple, rarely glandular punctate, with secretory cells containing resin, exstipulate; inflorescences thyrses, panicles, racemes or umbels, sometimes cauliflorous; flowers mostly bisexual, rarely the plants dioecious; sepals 5 (3–4), free or shortly connate; petals 5 (3–14), free or rarely shortly connate, sometimes adnate to the staminal tube;

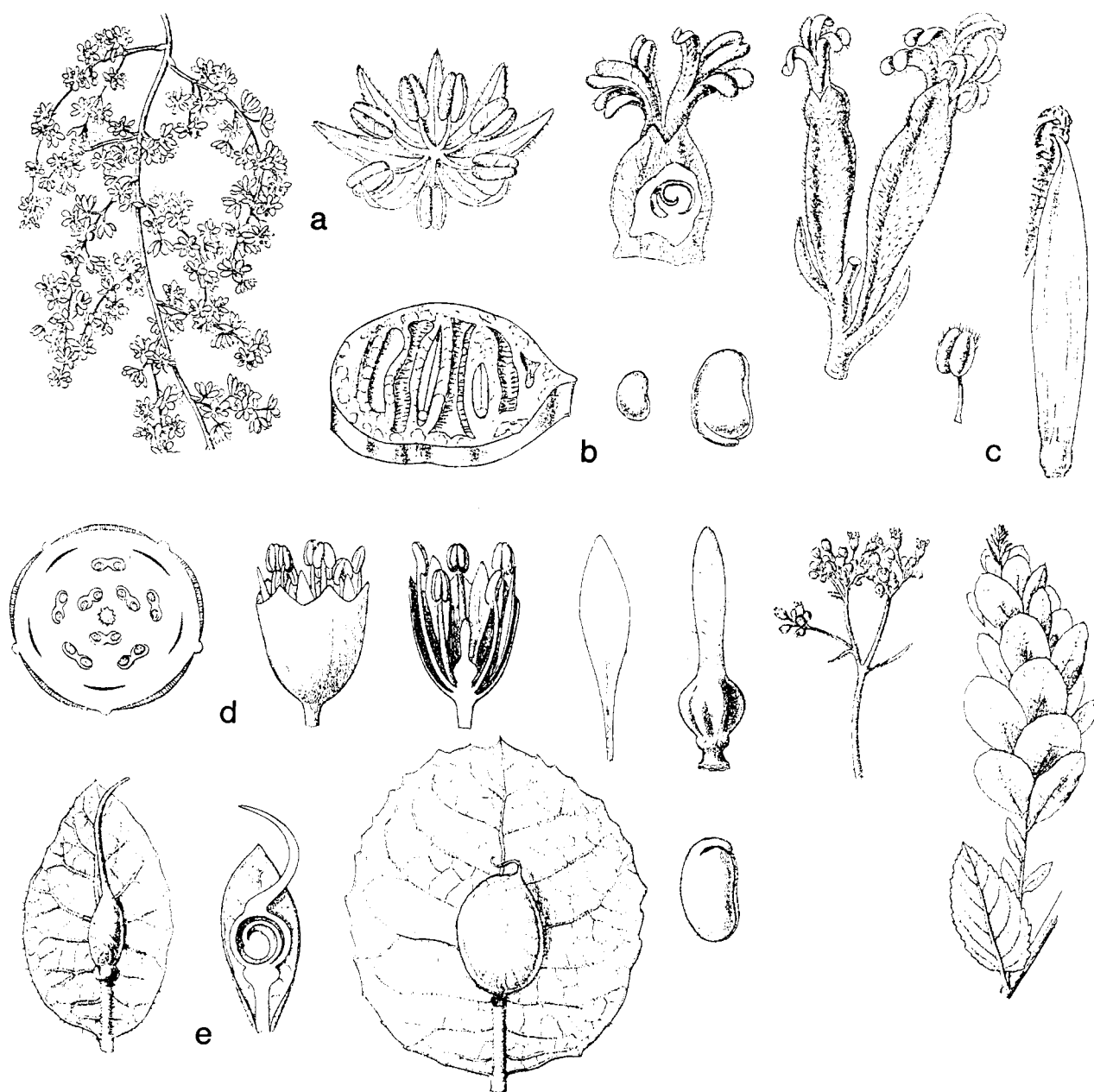


FIGURE 124.—ANACARDIACEAE: *a*, *Amphipterygium adstringens* part of ♂ inflorescence, ♂ flower, a pair of ♀ flowers, one with the ovary opened to show the solitary ovule, a pair of ♀ inflorescences, one with 1 flower the other with 2; *b*, c.s. through 2 fruits, seed, embryo; *c*, *Orthopterygium huaucui* stamen, fruit; *d*, *Dobinea delavayi* floral diagram of ♂ flower, ♂ flower, l.s. of same, petal, pistillode, part of ♂ inflorescence, ♀ inflorescence; *e*, ♀ flower on bract, l.s. of same, fruit on bract, embryo (after Hemsley, Franchet).

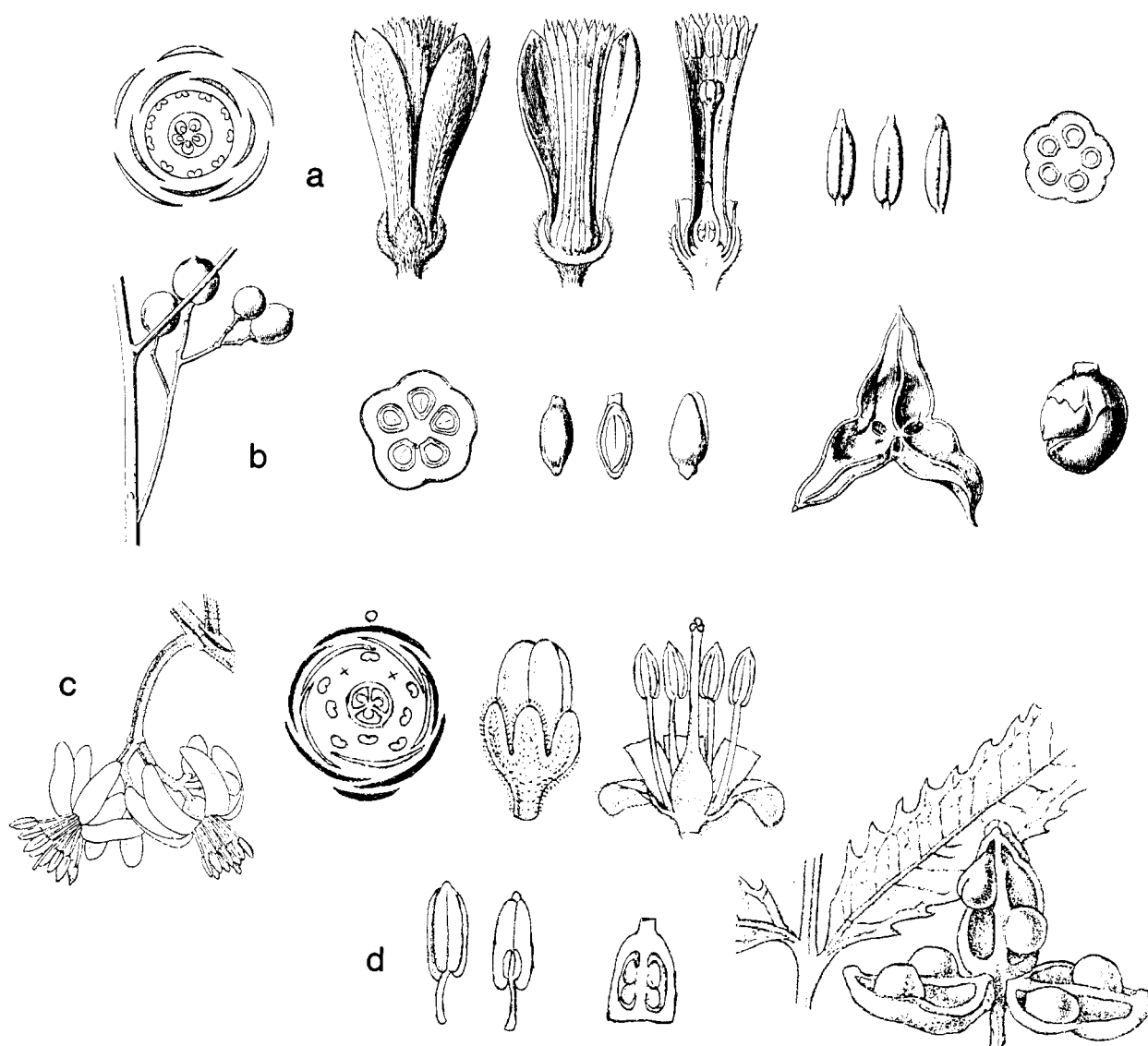


FIGURE 125.—MELIACEAE: *a*, *Melia azedarach* floral diagram, flower, same with part of perianth removed to show the staminal tube, l.s. of flower (upper part of petals cut off), views of anther, c.s. of ovary; *b*, part of infructescence, c.s. of fruit, seed, l.s. of same, embryo, *Trichilia richardiana* dehiscent fruit, seed with aril (after Martius, 1840–1906). AKANIACEAE: *c*, *Akania hillii* small part of inflorescence, floral diagram, bud, l.s. of flower; *d*, views of anther, l.s. of ovary, small part of leaf, dehiscent fruit (after Stapf, Maiden).

stamens 8 or 10 (3–25), the filaments mostly half way to completely connate, rarely free, (*Cedrela*, *Toona*), hypogynous; anthers about as long as wide, dorsifixed or basifixed, rarely apiculate; pollen 3–5-colporate (slightly rufoporate, or porate); usually a disk surrounding the base of the

ovary; pistil 1, the carpels 3–5 (2–20), style 1 or stigma sessile, stigma apical, often disciform or capitate, sometimes lobed; ovary superior 3–5(1–20)-locular, the ovules bitegmic, crassinucellar, anatropous, campylotropous or orthotropous, 2 (1–12) ovules per locule, axile; fruit a capsule,

berry, or rarely drupe, the seeds often winged; embryo straight, as long as the endosperm; cotyledons thin or thick, sometimes conferruminate, 3–3.2 times wider than the radicle, 0.8–0.9 the length of the embryo; endosperm moderate or 0.

Composition: 50 genera, ~1400 species.

Distribution: Pantropical and -subtropical, extending into warm temperate regions, particularly common as understory trees in rain forest.

SAPINDALES

Trees and shrubs, sometimes lianas usually with tendrils, rarely subherbaceous; xylem vessel perforation plates simple, scalariform with few to many bars, or both; tissue or sap sometimes with resin or latex-like secretions; leaves alternate, less commonly opposite, usually compound, sometimes simple, usually exstipulate; flowers bisexual or unisexual, occasionally zygomorphic, the parts hypogynous to slightly perigynous; sepals 5 (3–6), usually free, sometimes basally connate; petals 5 (0, 3–6), free, rarely shortly connate, sometimes with a basal ligulate scale; stamens 8 (4–20), usually in 2 series, the filaments elongate, free, inserted internal or external to a glandular disk, very rarely basally adnate to the petals; anthers dorsifixed, sometimes apiculate; pollen 3(2–4)-colporate, 3-colpate, 3–4-porate, rarely 4-rugorate or 4-ruporate; glandular disk usually present; pistil 1, the carpels 2–3 (–5), styles 1–2 (–4), the stigmas apical, less frequently decurrent; ovary superior, 3(1–5)-locular, the ovules 1–2 (–several) per locule, axile, rarely parietal, subbasal or subapical; fruit usually a loculicidal capsule, less often a schizocarp, berry, drupe, samara or nut, the seeds sometimes arillate; embryo large, often bent, folded or coiled, sometimes straight; endosperm usually absent, rarely copious.

Distribution: Pantropical, extending into temperate regions.

Chemistry: It is obvious that Aceraceae, Sapindaceae, and Hippocastanaceae are chemically closely related.

AKANIACEAE (Figure 125*c,d*).—Trees; xylem vessel perforation plates simple, also rarely scalariform with numerous bars in the young stem; scattered secretory cells in the leaf and cortex of the stem; leaves alternate, pinnately compound, serrate, exstipulate; inflorescences axillary or cauliflorous panicle or thyrse; flowers bisexual, the parts hypogynous; sepals 5, connate; petals 5, free; stamens 8 (9), in 2 series, one of 5 the other of 3, the filaments elongated, free; anthers about as long as wide, apiculate; pollen 3-colpate; disk absent; pistil 1, the carpels 3, style 1, stigmas apical, not enlarged; ovary 3-locular, the ovules 2 per locule, axile, bitegmic, crassinucellar, anatropous or semi-anatropous; fruit a loculicidal capsule, the seeds not arillate; embryo large, straight, the cotyledons thick, flattened, the radicle very short; endosperm copious, fleshy and oily, smelling of bitter almond.

Composition: 1 genus, 1 species.

Distribution: Eastern Australia.

SAPINDACEAE (Figure 126*b–e*).—Trees, shrubs, and lianas usually with tendrils, rarely subherbaceous; xylem vessel perforation plates simple; tissues usually with resin or latex-like secretions; leaves alternate or very rarely opposite, pinnately or ternately compound, or simple, the leaflets entire or toothed, with secretory cells, rarely stipulate (in the climbing species); inflorescences terminal or axillary cymes, often cincinni, or panicles; flowers actinomorphic or zygomorphic, rarely bisexual, usually the plants polygamodioecious, the parts hypogynous; sepals 5 (3–4), free or rarely connate; petals 5 (0, 3, 4), free, often with a basal ligulate scale; stamens 8 (4, 5, 10, 12–20), inserted internal to the disk, the filaments elongated, free; anthers about twice as long as wide, sometimes apiculate, dorsifixed near the base; pollen 3(2–4)-colporate or 3–4-porate; disk usually present, unilateral or annular; pistil 1, the carpels 3 (2–4), style 1 (2–4), stigmas terminal, lobed or punctiform; ovary 3(1–4)-locular, rarely incompletely so, the ovules bitegmic, crassinucellar, anatropous, campylotropous or semi-anatropous, 1 (2–several) per locule, axile or rarely parietal; fruit a capsule, berry,

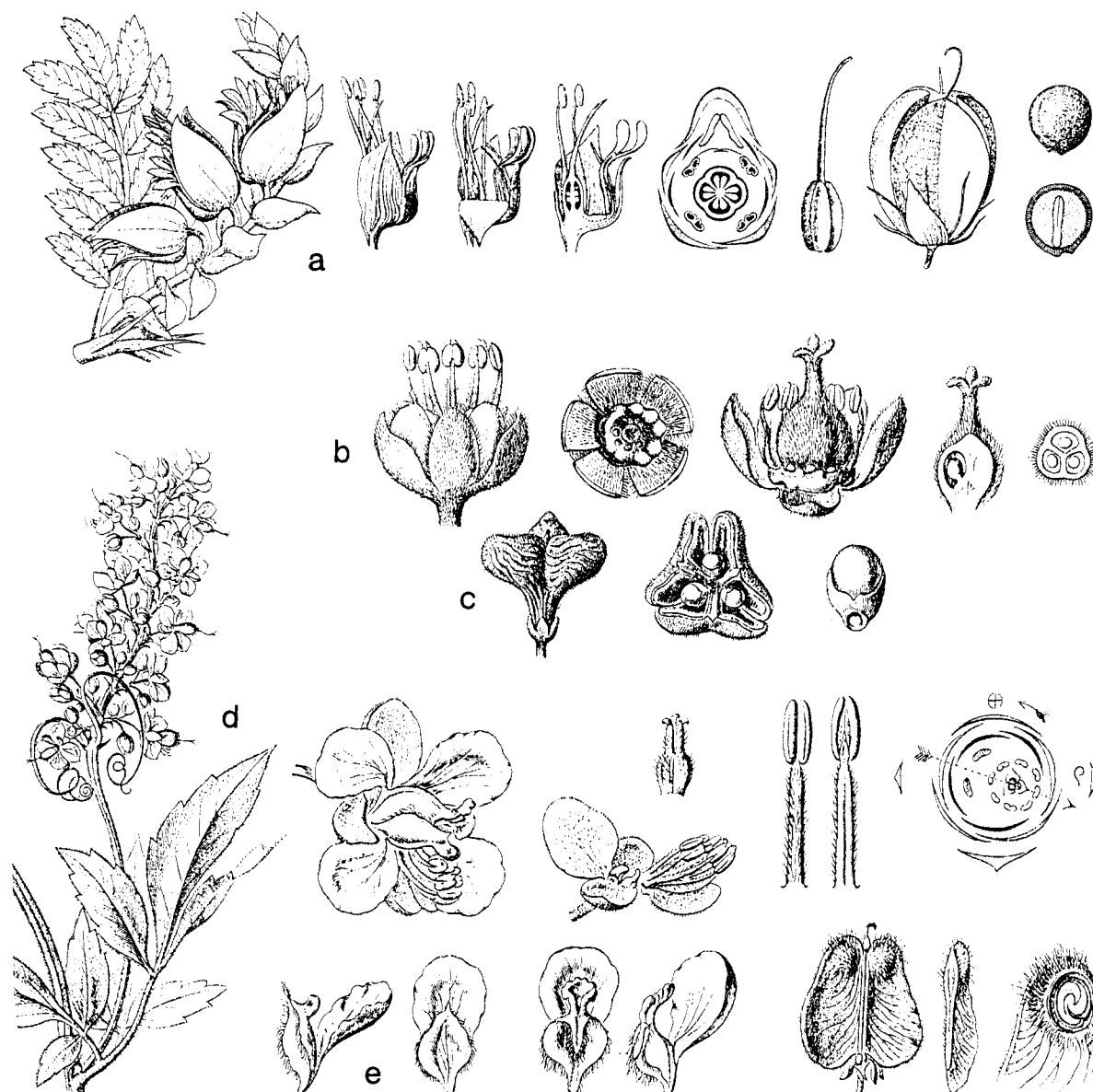


FIGURE 126.—MELIANTHACEAE: *a*, *Melianthus cosmus* inflorescence and leaf, *M. major* flower, same with 1 sepal reflexed, l.s. of flower, floral diagram, pistil, *M. cosmus* dehiscent fruit, seed and l.s. of same (after Baillon, 1866–1895; Schluss). SAPINDACEAE: *b*, *Cupania scrobiculata* ♂ flower, disk and base of sepals, ♀ flower with petals and several stamens removed, l.s. and c.s. of pistil; *c*, fruit, dehiscent fruit, arillate seed; *d*, *Serjania comata* inflorescence and leaf, *S. leptocarpa* ♂ flower, calyx showing insertion of stamens and disk (pistillode above), views of stamen, floral diagram; *e*, 2 views of lateral petal, 2 views of superior petal, *S. comata* fruit, mericarp, l.s. of part of same showing section of seed and embryo (after Martius, 1840–1906).

nut, samara, drupe or schizocarp, the seeds often arillate; embryo large, the cotyledons thin, often plicate or coiled, or thick and plano-convex, 0.6–0.9 the length of the embryo; endosperm 0.

Composition: 140 genera, 1500 species.

Distribution: Pantropical, especially America, relatively few in temperate United States, South Africa, Japan, Australia, and New Zealand.

MELIANTHACEAE (Figure 126a).—Shrubs and small trees; xylem vessel perforation plates simple; leaves alternate, pinnately compound, the leaflets toothed, stipulate; inflorescence a raceme; flowers bisexual, rarely the plants polygamodioecious, zygomorphic; sepals 5 (4), free or basally connate, unequal, one sometimes spurred or saccate; petals 5 (4), free, subperigynous; stamens 4–5, the filaments long, inserted internal to the disk, free or basally connate; anthers about as long as wide, dorsifixed; pollen 3-colporate, rarely also 4-rugorate; disk unilateral; pistil 1, the carpels 4–5 (–2); style 1, the stigma apical, not enlarged; ovary superior, 4–5(–2)-locular, the ovules 1–5 per locule, bitegmic, crassinucellar, anatropous; fruit a loculicidal capsule, the seeds sometimes arillate; embryo straight, 0.5 the length of the endosperm; cotyledons not broadened, 0.5 the length of the embryo; endosperm copious.

Composition: 2 genera, 15 species.

Distribution: Tropical to temperate southern Africa.

HIPPOCASTANACEAE (Figure 127a,b).—Trees and shrubs; xylem vessel perforation plates usually simple, also occasionally scalariform; secretion cells in the vegetative organs; leaves opposite, palmately compound, the leaflets serrate or entire, exstipulate; inflorescences terminal thyrses, racemes or cymes (cincinni); flowers zygomorphic, bisexual or the plants polygamomonoeious; sepals (4) 5, free or basally connate; petals (4) 5, free; stamens (5)–8, the filaments free, elongated, inserted interior to the disk; anthers about as long as wide, dorsifixed; pollen 3-colporate; disk solid, annular or unilateral; pistil 1, the carpels 3, style 1, stigma apical, punctiform; ovary superior, 3-locular, the ovules 2 per

locule, axile, bitegmic, crassinucellar, anatropous or anacampylotropous; fruit a loculicidal capsule, the seeds large, not arillate; embryo large, curved, the cotyledons conferruminate, much wider than the radicle ($10 \times ?$), 0.8 the length of the embryo; endosperm 0.

Composition: 2 genera, 15 species.

Distribution: Temperate eastern United States, California; southern Mexico to northwestern South America; southeastern Europe, disjunct in northern India, China, and Japan.

STAPHYLEACEAE (Figure 127c,d).—Trees and shrubs; xylem vessel perforation plates scalariform, usually with 20–30 bars, but up to 50 in species of *Turpinia*; leaves opposite or alternate, trifoliolate or pinnately compound, rarely unifoliolate, the leaflets serrate, stipulate rarely exstipulate; inflorescences terminal or axillary panicles or racemes; flowers bisexual or the plants polygamous, rarely dioecious, actinomorphic; sepals (3–) 5, free or connate, petals (3–) 5, free; stamens 5, free, the filaments elongated, inserted on or external to the disk; anthers about as long as wide, dorsifixed; pollen 3(2–4)-colporate or 4-ruporate; disk hypogynous or 0 (*Tapiscia*); pistil 1, the carpels 3 (2–4), styles 3–1, elongated, stigmas apical, punctiform; ovary superior, 3–2-locular, the ovules bitegmic, crassinucellar, anatropous sometimes becoming subcampylotropous, 1–several (12) per placenta, axile or subbasal; fruit a membranous apically dehiscent capsule, follicles, berry or drupe, the seeds often truncate basally; embryo straight, as long as the endosperm; cotyledons thin, flat, 4.4 times wider than the radicle, 0.8 the length of the embryo; endosperm moderate, fleshy.

Composition: 5 genera, 50 species.

Distribution: Southeastern Canada, eastern United States, California, Europe, and Asia Minor (*Staphylea*); Japan, China, and Indochina (*Euscaphis*); Sri Lanka, Japan, China to Malaya, tropical America (*Turpinia*); West Indies, Colombia, Peru (*Huerteia*); China (*Tapiscia*).

ACERACEAE (Figure 127e).—Trees and shrubs; xylem vessel perforation plates simple, rarely also foraminiate, the sap sometimes milky;

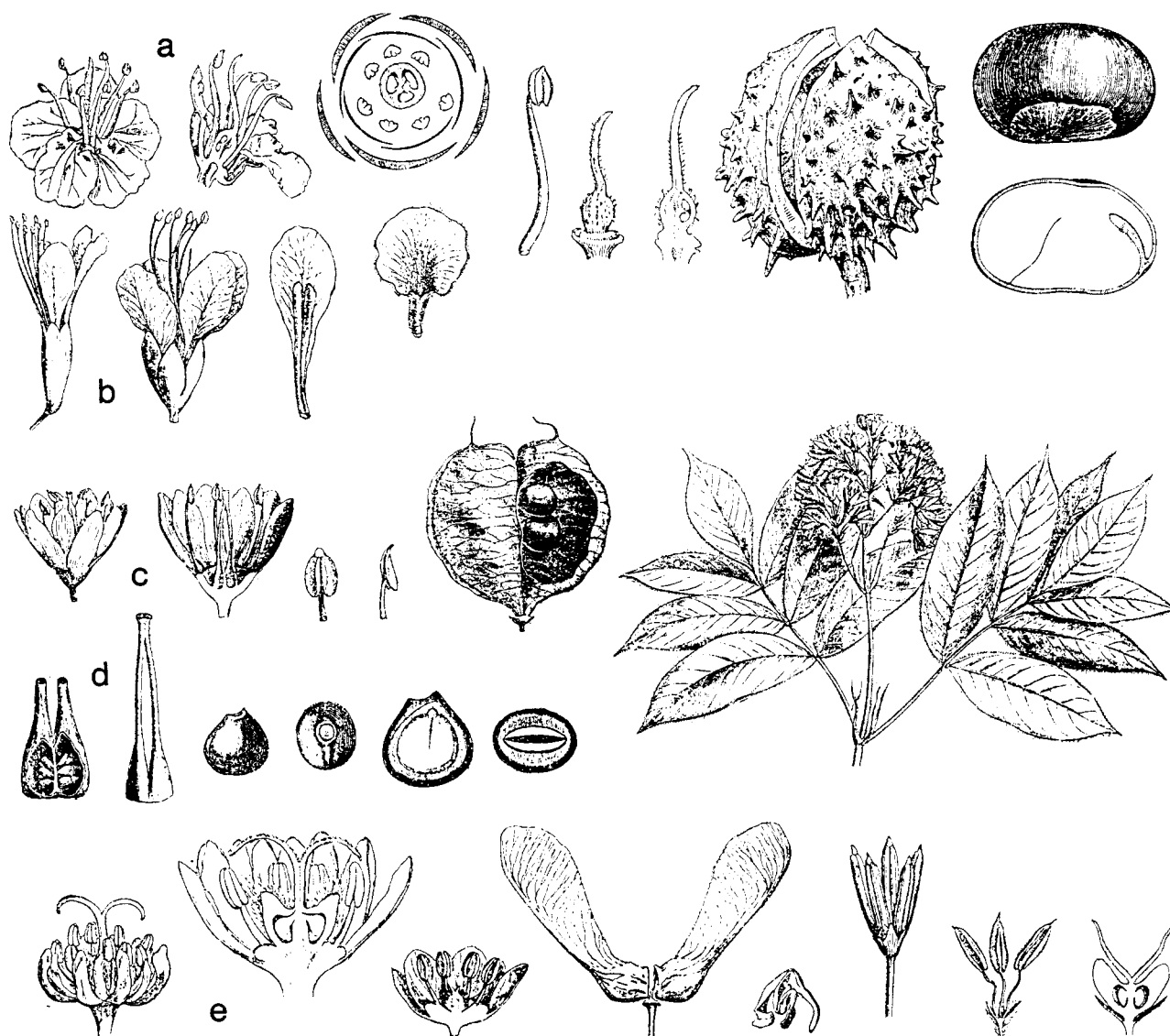


FIGURE 127.—HIPPOCASTANACEAE: *a*, *Aesculus hippocastanum* flower, l.s. of same, floral diagram, stamen, pistil, l.s. of same, dehiscent fruit, seed and l.s. of same; *b*, *A. pavia* flower, *Billia hippocastanum* flower, petal, *A. hippocastanum* petal (after Baillon, 1866–1895; Le Maout and Decaisne, 1873; Pax). STAPHYLEACEAE: *c*, *Staphylea pinnata* flower, l.s. of same, views of anther, fruit partly opened to show seeds, flowering twig; *d*, l.s. of pistil, pistil, views of seed, l.s. and c.s. of same (after Pax). ACERACEAE: *e*, *Acer pseudoplatanus* bisexual flower, l.s. of same, l.s. of ♂ flower, fruit separating into mericarps, embryo, *A. negundo* ♂ flower, l.s. of same, l.s. of ♀ flower (after Le Maout and Decaisne, 1873; Pax).

leaves opposite, usually simple, lobed or toothed, sometimes trifoliolate or pinnately compound, sometimes with elongated laticiferous cells, exstipulate; inflorescences terminal or axillary panicles, racemes, corymbs, spikes, umbels or fasci-

cles; plants polygamomonoecious or dioecious; sepals 5 (4), free or rarely basally connate; petals 5 (4 or 0), free; stamens 8 (4–10), the filaments free, elongated, inserted external to, on, or internal to the disk; anthers about as long as wide,

dorsifixed, rarely apiculate; pollen 3-colporate, 3-colpate, or 3-colporoidate; disk annular, lobed or separate glands, rarely absent; pistil 1, the carpels 2, rarely 3–5 in some flowers, styles 2, elongated, free or basally connate, the stigmas decurrent ventrally or papillose all around (*Acer negundo*); ovary superior, bilocular, the ovules bitegmic, crassinucellar, anatropous, semi-anatropous, or orthotropous, sometimes becoming campylotropous, 2 (1) per locule, axile; fruit a samaroid schizocarp; embryo coiled or bent, elongated, the cotyledons thin, irregularly folded, 0.6 the length of the embryo, 4 times wider than the radicle; endosperm 0.

Composition: 2 genera, 150 species.

Distribution: Temperate Northern Hemisphere and mountains of the tropics, centered in China, Japan, and eastern North America.

SABIACEAE (Figure 128*a–c*).—Trees and shrubs, often scandent, the leaves and flowers sometimes with obscure reddish glandular dots; xylem vessel perforation plates only simple or also scalariform, usually with few bars, but up to 30 in some species, occasionally reticulate or forminate; leaves alternate, simple or pinnately compound, entire or toothed, exstipulate; inflorescences axillary, terminal or both, panicles, rarely racemes, or the flowers solitary; flowers bisexual or the plants polygamodioecious; sepals 5 (4–6), basally connate; petals 5 (4–6), imbricate, free or basally connate, sometimes differing in size (*Meliosma*); stamens 5 (4–6), sometimes 3 of these staminodal (*Meliosma*), opposite the petals, free or basally adnate to the petals; anthers about as long as wide, sometimes didymous, dorsifixed or adnate, the connective sometimes enlarged; pollen 3-colporate (-colporoidate); disk annular or cupular, sometimes lobed or dentate, surrounding the base of the ovary; pistil 1, the carpels 2 (3), the styles elongated or short, loosely connate or free, the stigma(s) apical, minute, rounded or capitate; ovary superior, often compressed, 2(3)-locular, the ovules 2 (1) per locule, axile, sometimes subapical, unitegmic, the integument failing to grow over the nucellus, crassinucellar, semi-anatropous; fruit a drupelet

or schizocarp of 2 drupaceous or dry mericarps, sometimes 1 aborted, the seeds 1 or 1 per locule; embryo large, the cotyledons flat, fairly thick, usually folded or contorted, 0.2–0.5 the length of the embryo, 3.6–5.0 times wider than the radicle, the radicle cylindrical, bent against the cotyledons; endosperm very scanty or absent.

Composition: 4 genera, 80 species.

Distribution: Tropical America and tropical eastern Asia, extending into temperate Japan and Korea.

GERANIALES

Herbs and shrubs, less commonly trees, sometimes climbing; xylem vessel perforation plates simple, rarely also scalariform with fewer than 25 bars; leaves alternate, less often opposite or whorled, simple or compound, entire, toothed, dissected or lobed, stipulate or exstipulate; flowers bisexual, rarely unisexual, actinomorphic or zygomorphic, sometimes 2–3-morphic, i.e., the stamens and pistils varying in relative length in the same species; sepals 5 (3, 4), free or basally connate, one rarely spurred, rarely colored, rarely with large glands on the dorsal surface; petals 5 (0, 2, 4), free or shortly connate, rarely the laterals connate, rarely with a ligular attachment, often convolute in bud; stamens usually twice as many as the petals, sometimes the same number, rarely 3 times as many, sometimes 1–2 series staminodal, often obdiplostemonous, the filaments free or basally connate, very rarely higher or in bundles; anthers dorsifixed, rarely basifixed, very rarely connate; pollen 3 (2–4)-colpate, 3(4)-colporate, oligo-polyforate, rarely 6–12-rugulate, 4–6-rupate or ruplicate, or non-aperturate; glandular disk or separate glands often present; pistils 1, very rarely 5 (1–8), the carpels 3, 5 (1–12), styles 1–5, the stigmas apical, less commonly decurrent ventrally, rarely subsessile; ovary superior, 3, 5 (1–12)-locular, the ovules 1–2 (–several) per locule, axile, rarely subbasal; fruit a schizocarp, capsule, less commonly a berry, drupe or samara, rarely follicular, the seeds sometimes arillate; embryo large,

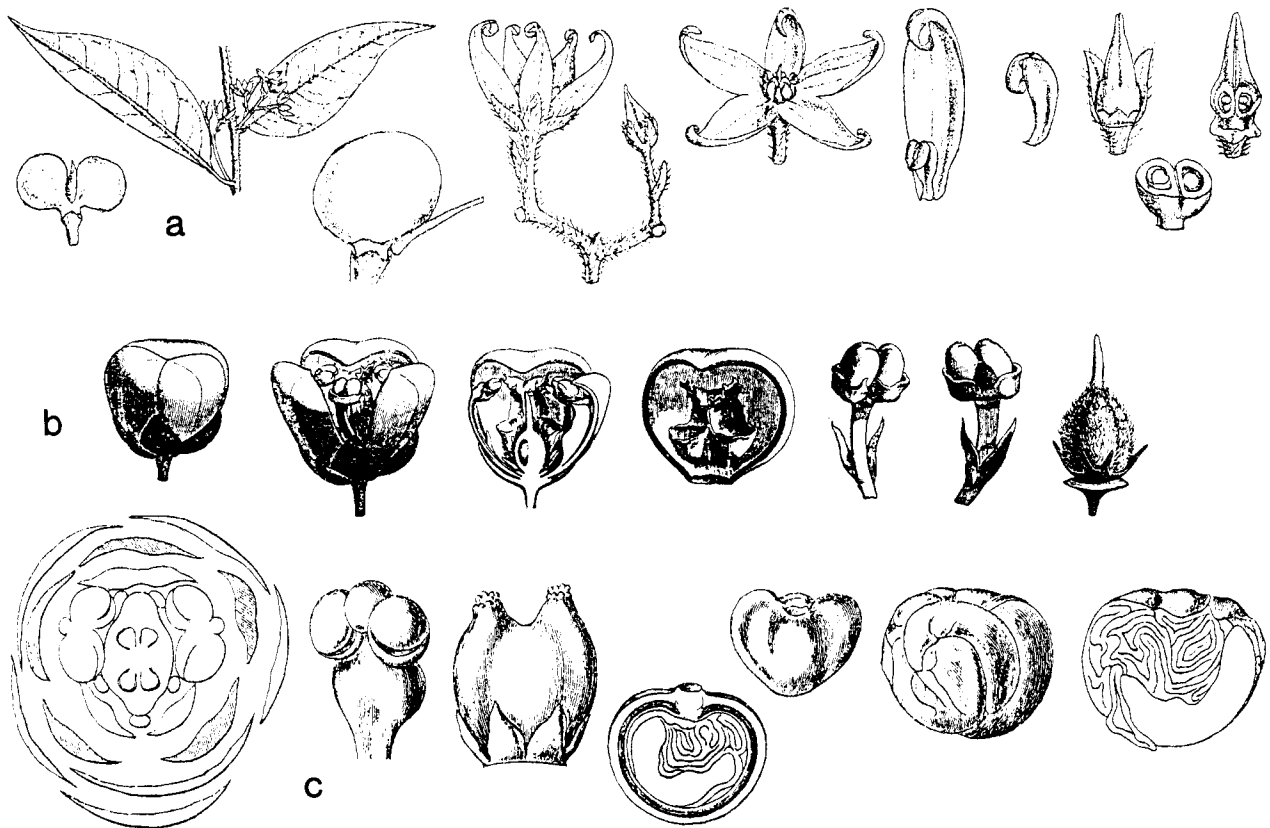


FIGURE 128.—SABIACEAE: *a*, *Sabia latifolia* fruit with 2 mericarps (reduced), *S. gracilis* axillary inflorescences, *S. latifolia* fruit with 1 mericarp, *S. gracilis* part of inflorescence, flower, petal with its superposed stamen, stamen, pistil with part of calyx and disk, pistil with part of ovary removed to show the ovules and c.s. of ovary; *b*, *Meliosma arnottiana* bud, flower, l.s. of same, petal with appendage, views of stamen, pistil and disk; *c*, *Ophiocaryon heterophyllum* floral diagram, stamen, pistil, l.s. of fruit, seed, embryo, l.s. of same (after Hemsley; Stapf; Baillon, 1866–1895; Martius, 1840–1906).

straight, arcuate or folded; endosperm absent to copious.

Distribution: Cosmopolitan in various habitats.

Chemistry: According to Hegnauer presence of mustard-oil glucoside and seeds with amyloid and eruca acid in Tropaeolaceae and Limnanthaceae strongly indicates that they are related. Zygophyllaceae also produces mustard-oil glycosides.

GERANIACEAE (Figure 129*a–c*).—Herbs and shrubs; xylem vessel perforation plates typically simple, occasionally reticulate or scalariform; leaves alternate or opposite, simple, dissected or

compound, lobed or toothed, stipulate; inflorescences axillary, cymose, subumbellate, or the flowers solitary; flowers bisexual, actinomorphic or slightly zygomorphic; sepals 5 (4), free or basally connate, one sometimes spurred; petals 5 (2–4) very rarely 0 (*Rhynchotheca*); stamens in 1–3 series of 5 (4) each, obdiplostemonous, the filaments elongated, usually connate basally, rarely connate in 5 bundles of 3 each (*Monsonia*); anthers about as long as wide, dorsifixed, rarely basifixed; pollen (2) 3-colpate, 3(4)-colporate or nonaperturate; glands usually present, alternate with the stamens; pistil 1, the carpels 5 (–3), styles 1 (–5), the stigmas apical, decurrent ventrally;

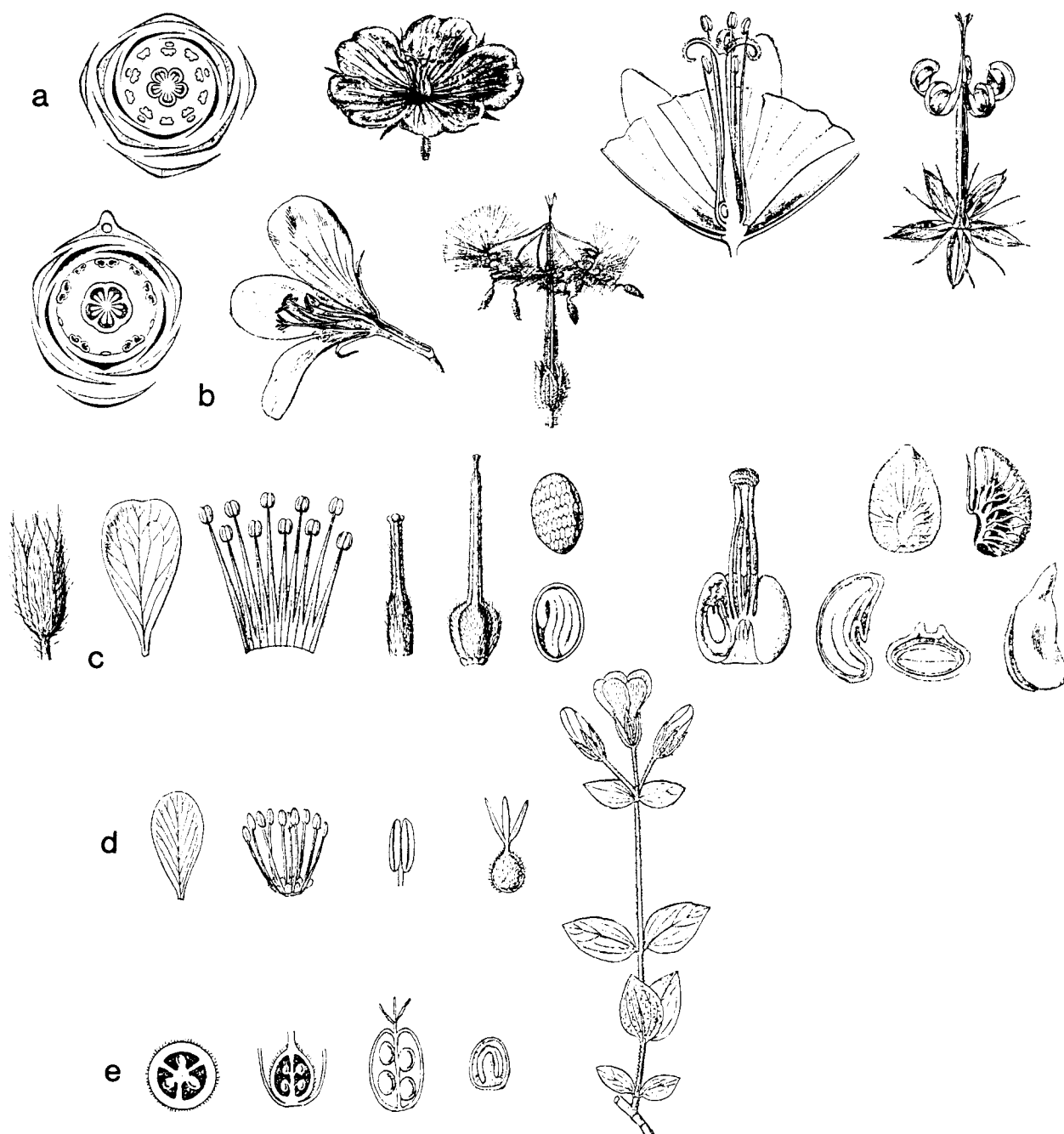


FIGURE 129.—GERANIACEAE: *a*, *Geranium sanguineum* floral diagram, flower, l.s. of same (perianth partly removed), dehiscent fruit; *b*, *Pelargonium inquinans* floral diagram, l.s. of flower, dehiscent fruit; *c*, *Geranium albicans* calyx, petal, androecium laid open, pistil, fruit, seed and l.s. of same showing the embryo, *Biebersteinia multifida* pistil with 1 carpel opened to show the ovule, views of a mericarp (above), l.s. and c.s. of a mericarp, embryo (after Baillon, 1866–1895; Martius, 1840–1906; Schnizlein). VIVIANIACEAE: *d*, *Viviania rosea* petal, stamens and glands, anther, pistil; *e*, c.s. and l.s. of ovary, l.s. of fruit, l.s. of seed, flowering stem (after Hutchinson, 1973).

ovary superior, 5(–3)-locular, the ovules 1–2, rarely more, per locule, axile, bitegmic, crassinucellar, anatropous, campylotropous or amphitropous; fruit a schizocarp, often beaked; embryo folded, the cotyledons 0.5 the length of the embryo, 3.5 times wider than the radicle; endosperm 0 or sparse (Biebersteinieae).

Composition: 10 genera, 760 species.

Distribution: Principally temperate and subtropical; temperate North America to Argentina; Eurasia except the arctic; Africa except the Sahara desert; eastern and southern Australia, New Zealand.

VIVIANIACEAE (Figure 129*d,e*).—Subshrubs and herbs; xylem vessel perforation plates simple; leaves opposite or verticillate, simple, entire, crenate or dentate, exstipulate; inflorescences axillary and terminal, subfasciculate to cymose-paniculate; flowers bisexual, the parts hypogynous; sepals (4–) 5, free or connate; petals (4–) 5 or 0, free; stamens 10 (8), free, the filaments filiform, the anthers slightly longer than wide, dorsifixed; pollen polyforate; disk glands 5, alternate with the petals; pistil 1, the carpels (2–) 3, the style 1, stigmas (2–) 3, linear; ovary (2–) 3-locular, not beaked, the ovules 1–2 per locule, axile; fruit a loculicidal capsule; embryo linear, arcuate or coiled, subperipheral, 1.6 times the length of the endosperm; cotyledons not broadened, 0.4 the length of the embryo; endosperm copious, fleshy.

Composition: 2 genera, 30 species.

Distribution: Southern Brazil, Chile.

LIMNANTHACEAE (Figure 130*a,b*).—Herbs; xylem vessel perforation plates simple; leaves alternate, pinnatisect, exstipulate; inflorescence terminal in a group of 3 flowers and flowers also solitary in leaf axils; flowers bisexual, actinomorphic; sepals 5–3, free, valvate; petals 5–3, free, sometimes contorted; stamens 10 or 6, the filaments elongated, free; anthers about as long as wide, dorsifixed; pollen 2-colpate (or colporate?); glands sometimes present next to the filaments; pistil 1, the carpels 5 or 3 (2), style 1, gynobasic, stigmas 5 or 3 (2), apical or slightly elongated; ovary deeply 5 or 3(2)-lobed, supe-

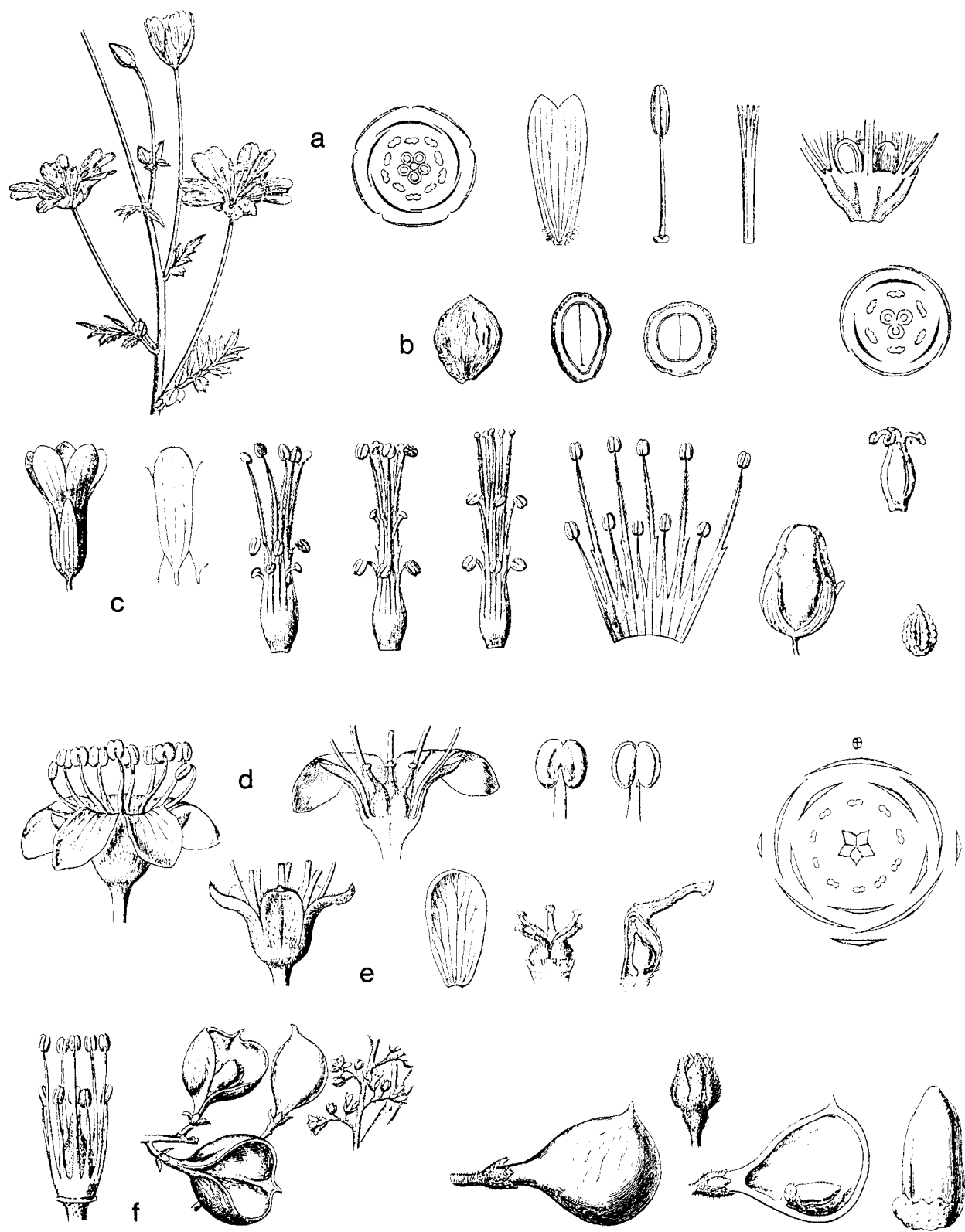
rior, the ovules 1 per locule, basal-axile, unitegmic, tenuinucellar, anatropous; fruit a schizocarp of 1–5 nutlets; embryo straight, the radicle invested; cotyledons thick, plano-convex, 0.75–0.9 the length of the embryo; endosperm 0.

Composition: 2 genera, 11 species.

Distribution: Moist habitats; western United States and adjacent Canada, especially California, one species reaching the eastern United States.

OXALIDACEAE (Figure 130*c*).—Herbs and shrubs, rarely trees (*Averrhoa*); xylem vessel perforation plates simple; leaves alternate, digitately or pinnately compound, sometimes unifoliolate, the leaflets entire (except some *Hypseocharis*), exstipulate; inflorescences axillary cymes, subumbellate, or cauliflorous racemes or thyrses (*Averrhoa*), or the flowers solitary; flowers bisexual, actinomorphic, heterostyled; sepals 5, basally connate; petals 5, free or shortly connate, contorted in bud; stamens 10 or 15, 5 sometimes staminodal, in 2 or 3 series, weakly obdiplostemonous, the filaments shortly connate; anthers about as long as wide, dorsifixed; pollen 3(4)-colpate, 4-rupate, 3-colporate, or 3-colporoidate; disk absent; pistil 1, the carpels 5, styles 5 or 1, free or connate (*Hypseocharis*), stigma generally capitate; ovary superior, 5-locular, the ovules 1 or several per locule, axile, bitegmic, tenuinucellar, anatropous; fruit a loculicidal capsule, rarely a schizocarp (*Biophytum*), rarely a 5-lobed berry (*Averrhoa*); seeds sometimes arillate; embryo straight or cochlear (*Hypseocharis*), 0.9 the length

FIGURE 130.—LIMNANTHACEAE: *a*, *Limnanthes douglasii* part of flowering shoot, floral diagram, petal, stamen and gland, style and stigmas, l.s. of base of flower showing ovule in a carpel; *b*, fruitlet, l.s. and c.s. of same, *Floerkea proserpinacoides* floral diagram (after Le Maoout and Decaisne, 1873). OXALIDACEAE: *c*, *Oxalis elatior* flower, petal, essential organs—brevistylous, intermediate and longistylous forms, androecium of microstylous flower laid open, fruit, pistil (microstylous form), *O. delicata* seed (after Martius, 1840–1906). CONNARACEAE: *d*, *Rourea cuspidata* flower, l.s. of same (anthers removed), views of anther (from bud); *e*, calyx, petal, gynoecium, l.s. of 1 pistil, *R. induta* floral diagram; *f*, *Connarus patrisii* essential organs, dehiscent fruit and small part of inflorescence, *C. suberosus* fruit, calyx, l.s. of fruit, seed with aril (after Martius, 1840–1906).



of the endosperm; cotyledons elliptic, moderately thick, 2.4–2.5 times wider than the radicle, 0.5–0.7 the length of the embryo; endosperm moderate, fleshy.

Composition: 8 genera, ~900 species.

Distribution: Cosmopolitan except arctic and cool temperate Northern Hemisphere; mainly tropical and subtropical Asia, Africa, and America, often at high elevations.

CONNARACEAE (Figure 130*d–f*).—Lianas, more rarely trees and shrubs; xylem vessel perforation plates simple; secretory cavities sometimes present in the parenchyma of the tissues; leaves alternate, usually compound, sometimes unifoliate, the leaflets entire, very rarely with 2–3 teeth, pulvini present, exstipulate; inflorescences terminal, axillary or at nodes of fallen leaves, panicles, fascicles or spikes; flowers bisexual, perhaps sometimes functionally unisexual, actinomorphic, the parts hypogynous, sometimes heteromorphic with styles and stamens of 2–3 different lengths in the same species; rarely the plants dioecious; sepals 5 (4–3), free or shortly connate, imbricate or valvate; petals 5 (4), free, rarely slightly connate, rarely loriform and circinate in bud; stamens 5 (4) or 10 (8) in 2 series, the inner sometimes staminodial, the filaments elongated, often shortly connate, the anthers dorsifixed, about as long as wide; pollen 3–4-colpate, 3-colpoidate, colporate or colpoidate; disk present or absent; pistils 5 (1–8), unicarpellate when one, sometimes narrowed to a stipe, sometimes very slightly connate laterally and/or ventrally at the base, the style somewhat elongated, the stigma apical, capitate or obscurely bilobed; ovules 2 (3), ventral or subbasal, bitegmic, crassinucellar, hemianatropous; fruit usually follicular, sometimes dehiscent along both sutures or rarely indehiscent; seed 1 (2), often arillate or sarcotestal, the embryo straight, 0.4–0.9 the length of the endosperm; cotyledons flat or plano-convex, 0.7–0.9 the length of the embryo, 2–7.5 times wider than the radicle, the latter sometimes invested; endosperm copious, scanty or 0, hard or fleshy, sometimes oily.

Composition: ~20 genera, ~350 species.

Distribution: Pantropical, especially Asia, extending into temperate China, Australia, and South Africa.

TROPAEOLACEAE (Figure 131*a–c*).—Succulent prostrate or twining herbs containing mustard-oil; xylem vessel perforation plates usually simple but sometimes also reticulate; leaves alternate, or the lower opposite, simple, usually peltate, sometimes lobed or the margin sinuate, rarely compound, sometimes dotted, exstipulate or stipulate; flowers axillary, solitary, bisexual, zygomorphic; sepals 5, shortly connate, colored, the dorsal one produced into a spur; petals 5 (2), free, inserted on the calyx; stamens 8, the filaments elongated, free; anthers about as long as wide, basifixed; pollen 3-colporate; pistil 1, the carpels 3, style 1, elongated, stigmas 3 apical-linear; ovary superior, 3-locular, the ovules 1 per locule, axile, bitegmic, tenuinucellar, anatropous; fruit a schizocarp of 3 cocci, rarely a berry, or samara (*Magallana*); embryo straight, the radicle invested; cotyledons thick, plano-convex, 0.8 the length of the embryo; endosperm 0.

Composition: 2 genera, 80 species.

Distribution: Mainly in mountains from southern Mexico to Chile and Argentina, but extending over most of the South America, in various habitats from cold mountain heights to rain forest and arid regions.

BALSAMINACEAE (Figure 131*d*).—Succulent herbs, rarely shrubs; xylem vessel perforation plates simple; leaves alternate, rarely opposite or whorled, simple, toothed, exstipulate; inflorescences axillary, subumbellate, racemiform or the flowers solitary; flowers bisexual, zygomorphic; sepals 3 (5), free, often colored, the posterior one produced into a nectariferous spur; petals 5, free or the laterals connate; stamens 5, the filaments short, broad, apically connate; anthers small, about as long as wide, connate into a cap over the stigma; pollen 3–4-colpate; disk absent; pistil 1, the carpels 5, stigmas 5, more or less obscure, apical, subsessile; ovary superior, 5-locular, the ovules 3–several per locule, axile, bitegmic, tenuinucellar, anatropous; fruit a succulent capsule dehiscent elastically, rarely a

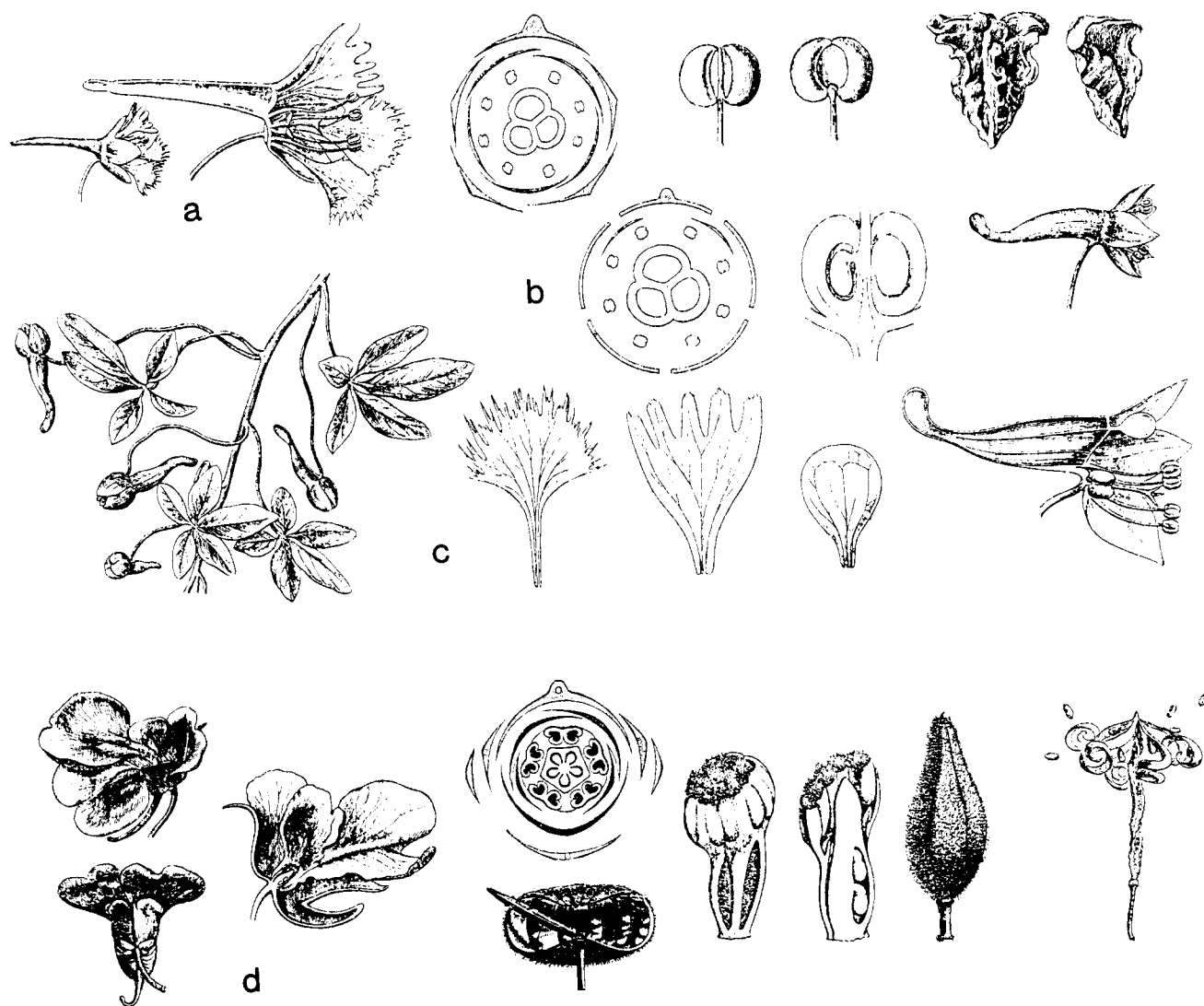


FIGURE 131.—TROPAEOLACEAE: *a*, *Tropaeolum brasiliense* flower, l.s. of same, floral diagram, views of anther, views of mericarp; *b*, *T. pentaphyllum* floral diagram, l.s. of ovary, flower; *c*, part of shoot in bud, *T. brasiliense* inferior petal, superior petal, *T. pentaphyllum* superior petal, l.s. of flower (after Martius, 1840–1906). BALSAMINACEAE: *d*, *Impatiens balsamina* 2 views of flower, l.s. of same, floral diagram and dehiscent fruit, essential organs, l.s. of same, fruit, *I. noli-tangere* dehiscent fruit (after Baillon, 1866–1895).

berry; embryo straight, the cotyledons moderately thick, plano-convex, 0.9 the length of the embryo, 3 times the width of the radicle; endosperm 0.

Composition: 4 genera, 500 species.

Distribution: Mainly tropical Asia and Africa, a few species in temperate Northern Hemisphere and Africa.

STACKHOUSIACEAE (Figure 132*a,b*).—Small herbs with a woody rhizome, with a rubber-like substance(?); xylem vessel perforation plates simple; leaves rarely absent, alternate, simple, entire, exstipulate; inflorescence a terminal cyme, raceme, spike, panicle, fascicle, rarely umbel, or the flower solitary; flowers bisexual; sepals 5, basally connate into a calyx-tube, the lobes im-

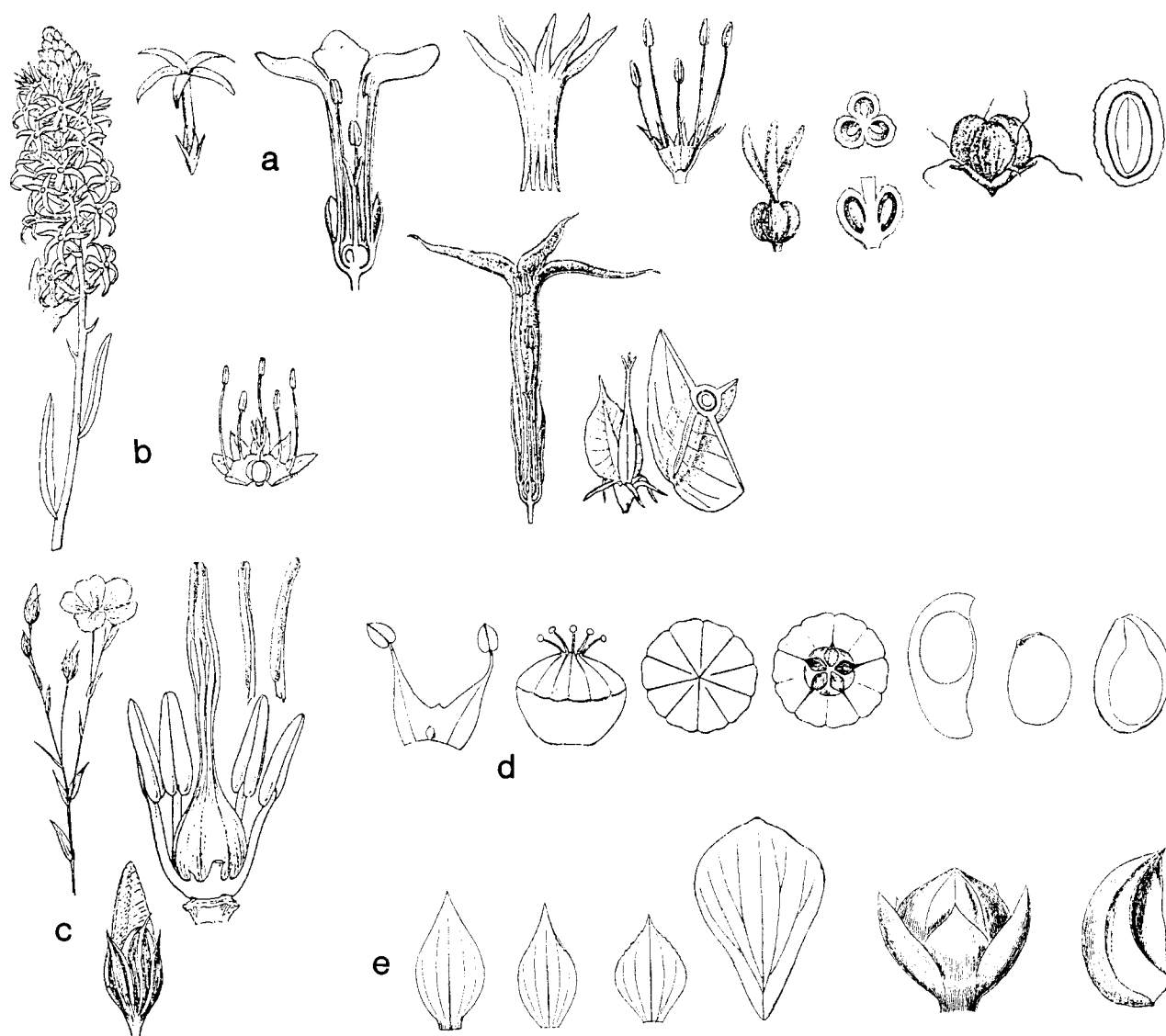


FIGURE 132.—STACKHOUSIACEAE: *a*, *Stackhousia monogyna* flower, l.s. of same, corolla laid open showing separations at base, calyx laid open showing insertion of stamens, pistil, c.s. and l.s. of ovary, fruit, *S. pulvinaris* l.s. of seed; *b*, *Stackhousia* sp. inflorescence, flower laid open (corolla removed), *Tripterococcus brunonis* l.s. of flower, part of fruit, c.s. of one of its cocci (after Baillon, 1866–1895; Lindley, 1853; Hutchinson, 1973; Pax). LINACEAE: *c*, *Linum usitatissimum* flowering shoot, bud, essential organs and 2 views of a stigma; *d*, *L. selaginoides* part of staminal tube laid open, pistil, fruit from above and below, l.s. of a hemicarpel in fruit, seed, l.s. of same showing embryo; *e*, *L. junceum* three of the sepals, petal, fruit with calyx, hemicarpel in fruit (after Johnson; Martius, 1840–1906).

bricate; petals 5, free or connate, perigynous; stamens 5, alternipetalous, the filaments short or elongated, inserted at the apex of the calyx-tube; anthers somewhat elongated, basifixed or sub-

basifixed, sometimes the connective produced apically; pollen 3-colporate; disk lining the calyx-tube; pistil 1, the carpels 3 (2–5), styles 3 (2–5), free or connate, sometimes with a discoid collar

beneath the 3 (2–5) stigma lobes, stigmas decurrent ventrally; ovary superior, 3(2–5)-locular, the ovules 1 per locule, basal, bitegmic, tenuinucellar, anatropous; fruit a schizocarp of 3 (2–5) cocci, leaving a columella, the cocci sometimes winged; embryo large, straight, 0.9 the length of the endosperm, elliptic in longitudinal section, the cotyledons gradually grading into the radicle; cotyledons 0.7 the length of the embryo; endosperm moderate, fleshy.

Composition: 3 genera, 25 species.

Distribution: Dry habitats, centered in Australia, extending to New Zealand, New Guinea, and the Philippines.

LINACEAE (Figure 132*c–e*).—Trees, shrubs, and herbs, sometimes climbing with hooks on the inflorescence; xylem vessel perforation plates simple or scalariform with less than 25 bars; leaves alternate or rarely opposite (*Aneulophus*, *Linum* spp., *Radiola*), simple, entire, rarely toothed (*Hugonia*), usually stipulate; inflorescence dichasium, cincinnus, thyrse, sometimes appearing to be a raceme; flowers bisexual, actinomorphic, sometimes heterostyled; sepals 5 (4), free or basally connate; petals 5 (4), free, rarely with a ligular attachment, contorted in bud, caducous; stamens as many as or twice as many as the petals, very rarely 15 and then some staminodal (*Roucheria* sp.), weakly obdiplostemonous, the filaments basally connate, sometimes 5 or 10 tooth-like staminodes present; anthers about as long as wide; pollen 3(4)-colpate, occasionally 6-rugate, polyforate or nonaperturate; disk 0 or an intra- or extra-staminal annulus; pistil 1, the carpels 5 (3–4), styles 5 (3–4), filiform, free or more rarely connate, the stigmas apical, capitate; ovary superior, 5(3–4)-locular or secondarily 10-locular, the ovules 2 (1) per carpel, axile, bitegmic, crassinucellar or tenuinucellar, anatropous; fruit a septicidal capsule or drupe (Hugoniaceae); seeds compressed, sometimes arillate; embryo straight, 0.97 the length of the endosperm; cotyledons moderately thick, twice as wide as the radicle, 0.7 the length of the embryo; endosperm copious or scanty, fleshy.

Composition: 13 genera, ~300 species.

Distribution: Principally temperate; cosmopolitan except for the arctic and cool temperate regions of the Northern Hemisphere.

ERYTHROXYLACEAE (Figure 133*a,b*).—Small trees and shrubs; xylem vessel perforation plates simple, rarely a few scalariform; leaves alternate, simple, entire, the stipule intrapetiolar; inflorescences axillary fascicles or the flowers solitary; flowers bisexual or the plants rarely subdioecious, actinomorphic, usually heterostyled; sepals 5, free or shortly connate; petals 5, free, mostly with a ventral ligulate bifid appendage or callosity, convolute or imbricate; stamens 10 in 2 series, obdiplostemonous, the filaments elongated, basally connate; anthers small, about as long as wide; pollen 3-colporate; glandular tissue external to filament tube; pistil 1, the carpels 3 (2 in *Nectaropetalum*), the styles 3 (1 in *Nectaropetalum*), free or basally connate, the stigmas apical, obliquely clavate or capitate; ovary superior, 3-locular, mostly only 1 of these fertile, with 1–2 axile, bitegmic, crassinucellar, anatropous or semi-anatropous ovules; fruit a drupe; embryo straight, 0.9 the length of the endosperm; cotyledons thin, 2.5 times wider than the radicle, 0.4–0.6 the length of the embryo; endosperm copious, fleshy, rarely 0.

Composition: 4 genera, 250 species.

Distribution: Centered in the Andes and Amazon basin; tropical America to part of temperate South America; tropical and subtropical Africa, Madagascar; Indochina, the East Indies, and northeastern Australia.

ZYGOPHYLLACEAE (Figure 133*c,d*).—Shrubs and herbs, rarely trees, sometimes the wood resinous; xylem vessel perforation plates simple; leaves opposite or rarely alternate, pinnately compound or 2 (3) foliolate, the leaflets entire, or simple and sometimes multifid (*Peganum*), stipulate or exstipulate; inflorescences terminal or axillary cincinni, compound, or the flowers solitary; flowers bisexual or rarely the plants dioecious (*Neoluederitzia*), actinomorphic or rarely zygomorphic, the parts hypogynous, very rarely subperigynous (*Sericodes*); sepals 5 (4), free or rarely basally connate; petals 5 (4), rarely 0,

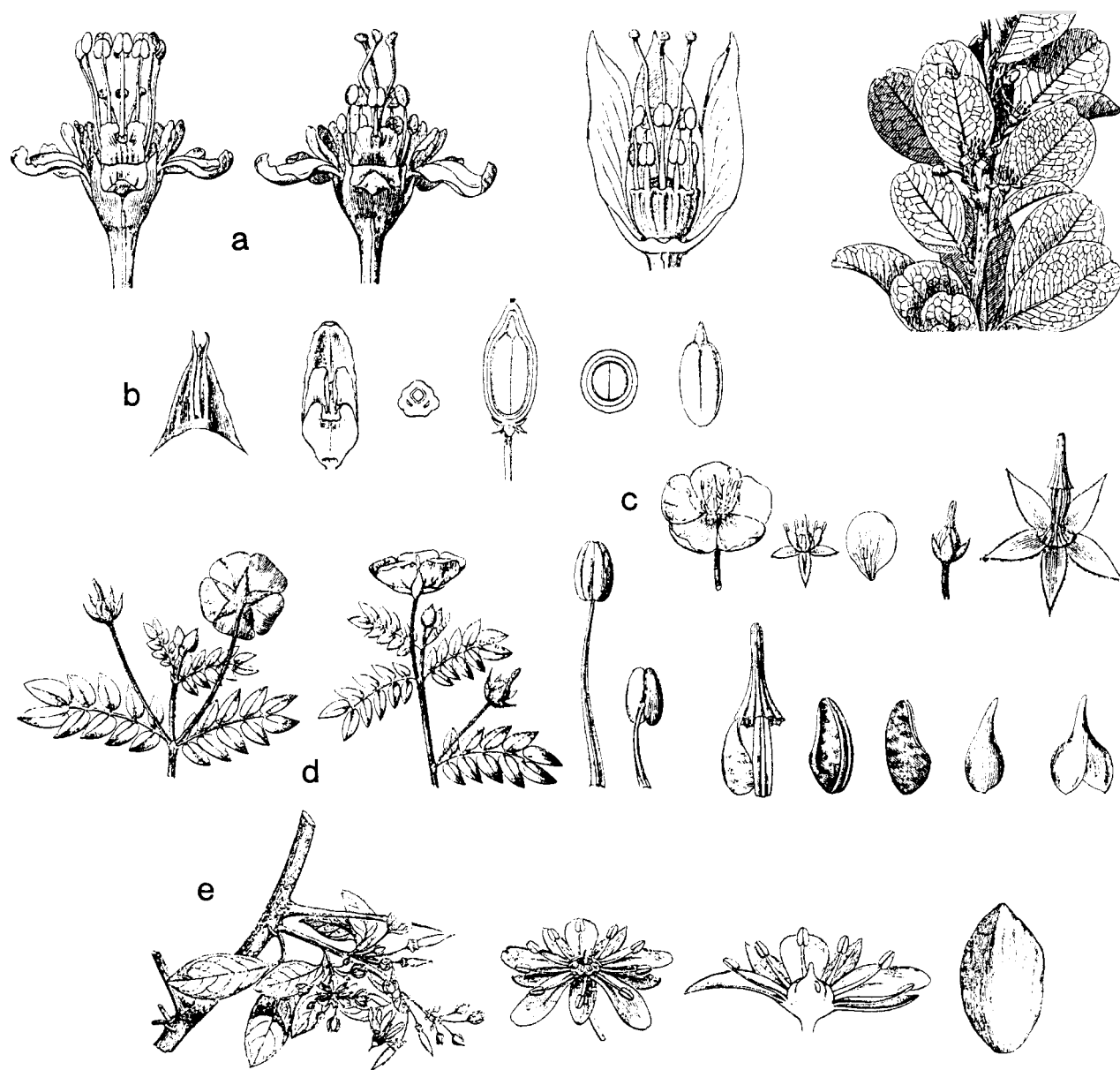


FIGURE 133.—ERYTHROXYLACEAE: *a*, *Erythroxylum coelophlebium* brevistylous flower, longistylous flower, *E. macrocnemium* longistylous flower with petals and 2 sepals removed, *E. vacciniifolium* part of a flowering twig; *b*, *E. coelophlebium* scale from twig, *E. macrocnemium* internal face of petal with appendage, *E. coelophlebium* c.s. of ovary, *E. buxus* l.s. and c.s. of fruit, embryo (after Martius, 1840–1906). ZYGOPHYLLACEAE: *c*, *Kallstroemia tribuloides* flower, same with petals removed, petal, fruit, dehiscent fruit; *d*, flowering shoots with 2 views of flower, views of stamen, dehiscent fruit with 1 remaining mericarp, 2 views of mericarp, embryo, same with cotyledons separated (after Martius, 1840–1906). BALANITACEAE: *e*, *Balanites aegyptiaca* flowering twig, flower, l.s. of same, dried fruit (after Baillon, 1840–1906).

free; stamens (3) 4–15, in 1–3 series, obdiplostemonous, the filaments elongated, free, often with a ventral ligular appendage; anthers about as long as wide, dorsifixed; pollen 3-colpate, 3(4)-colporate, 3-colporoidate, 4(5)-ruplicate, polyforate; disk usually present; pistil 1, the carpels 5 (2–12), style 1, short, the stigmas apical; ovary 5(2–12)-locular, the ovules 1 to ∞ per locule, axile, bitegmic, crassinucellar, anatropous; fruit usually a loculicidal and/or septicidal capsule, or cocci, rarely a berry (*Peganum*) or drupe (*Nitraria*); embryo straight or slightly curved, 0.7 to as long as the endosperm; cotyledons 1.3 times wider than the radicle, 0.5–0.7 the length of the embryo, the radicle sometimes invested; endosperm scanty or 0, hard.

Composition: 25 genera, 250 species.

Distribution: Mainly arid or salt habitats; mostly tropical and subtropical, extending into the temperate zones; southern United States to southern South America along the Andes; most of Africa, southern half of Eurasia, western East Indies, and Australia.

BALANITACEAE (Figure 133e).—Shrubs and small trees with bitter bark; xylem vessel perforation plates simple; leaves alternate, 2-foliate, the leaflets entire, not punctate, exstipulate; inflorescences axillary umbelliform clusters; flowers bisexual; sepals 5, free; petals 5, free; stamens 10, the filaments elongated, inserted outside the disk; anthers about as long as wide, dorsifixed; pollen 3-colporate, occasional grains 6-rugulate; disk thick, surrounding the base of the ovary; pistil 1, the carpels 5, style 1, very short, stigma apical, punctiform; ovary superior, 5-locular, the ovules 1 per locule, axile-subapical, bitegmic, crassinucellar, semi-anatropous or campylotropous; fruit a drupe, the seed 1; embryo ovoid, green, the cotyledons thick, plano-convex, corrugated or 2-lobed; endosperm 0.

Composition: 1 genus, 20 species.

Distribution: Tropical Africa to Burma.

MALPIGHIACEAE (Figure 134a–c).—Shrubs, lianas, and small trees; xylem vessel perforation plates simple; leaves opposite, very rarely alternate or ternate, simple, entire, rarely sinuate-

serrate or lobate, with hairs often appressed and medifixed and glands often present either on the petiole or on the lower surface, stipulate or rarely exstipulate; inflorescences terminal or axillary racemes; flowers usually bisexual, sometimes dimorphic, sometimes cleistogamous, rarely the plants polygamous, actinomorphic or slightly zygomorphic, the parts hypogynous or nearly so; sepals 5, mostly free, sometimes basally connate, often with 2 large glands on the dorsal surface of some or all; petals 5, free, convolute in bud; stamens mostly 10, in 2 series, obdiplostemonous, sometimes 5 reduced to staminodes, the filaments elongated, often basally connate; anthers 1–2 times as long as wide, the connective sometimes apically produced, dehiscence longitudinal or by a pore or pore-like slit; pollen 3–5-colporate, oligoforate, polyforate, oligoporate, 6–12-rugulate; disk small; pistil 1, the carpels 3 (1–4), styles usually free, united to the apex in *Bunchosia decussiflora*, stigmas apical, punctiform or capitate; ovary 3(1–4)-locular, the ovules bitegmic, crassinucellar, anatropous, semi-anatropous or campylotropous, 1 per locule, axile; fruit most frequently a schizocarp, often samaroid, sometimes a loculicidal capsule, more rarely a drupe; embryo straight, arcuate or rarely circinate, the radicle sometimes partly invested, the plumule sometimes evident; cotyledons sometimes plano-convex or one enlarged and thick and the other reduced, 3.3–6.0 times wider than the radicle, 0.5–0.8 the length of the embryo; endosperm 0.

Composition: 60 genera, 800 species.

Distribution: Forests and open areas; pantropical, extending into the warm temperate regions of America, Africa, and Asia; centered in South America.

POLYGALALES

Shrubs, herbs, and trees, sometimes climbing, very rarely saprophytes or parasites, sometimes resinous; xylem vessel perforation plates simple; interxylary or intraxylary phloem sometimes present; leaves alternate, less commonly oppo-

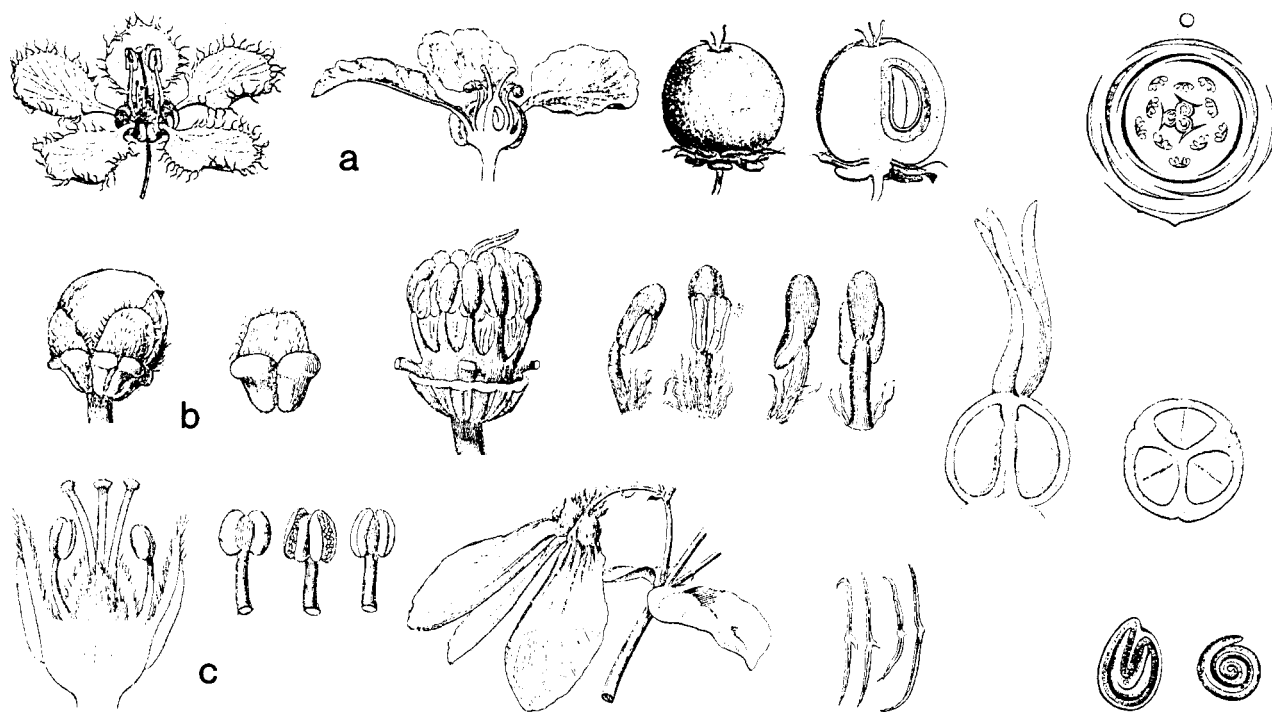


FIGURE 134.—MALPIGHIACEAE: *a*, *Gaudichaudia congestiflora* flower, *Malpighia nitida* l.s. of flower, fruit, l.s. of same, *Aspidopterys roxburgiana* floral diagram; *b*, *Byrsonima umbellata* bud, sepal with 2 glands, essential organs, 4 views of stamen, l.s. and c.s. of ovary; *c*, *Heteropterys pruinosa* l.s. of flower without petals, views of anther, fruit, *Tetrapteryx maranhamensis* hairs, *Thryallis brasiliensis* l.s. of seed, *Byrsonima spicata* embryo (after Baillon, 1866–1895; Martius, 1840–1906; Niedenzu; Jussieu).

site, simple, entire, usually exstipulate; flowers bisexual, usually zygomorphic; sepals 5 (4), free or rarely shortly connate, the inner two often colored, one rarely spurred; petals 1, 3–5 (0), free or 3 connate, 2 sometimes much smaller than the others, sometimes 1 larger and gibbous or spurred; stamens 1–12, in 1–2 series, some sometimes staminodal, the filaments connate or free, often inserted on the petals; anthers basifixed or dorsifixed, dehiscing by an apical pore or longitudinally, very rarely transversely; pollen 3-polycolporate (-ruporate, 3–4-porate, rugoidate); glandular disk rarely present; pistil 1, the carpels 2–3 (5), style 1, the stigma(s) apical; ovary superior, 2–3(1–5)-locular, the ovules 1–2(–several) per locule, axile, rarely apical or parietal; fruit a loculicidal or septicidal capsule, less commonly a nut, drupe, berry, samara, or achene,

the seeds often hairy, sometimes winged; embryo large, straight, rarely folded or convolute; endosperm usually copious, sometimes absent.

Distribution: Cosmopolitan, except the arctic, in various habitats.

Chemistry: Polygalaceae are rich in triterpenoid saponin, sinapic acid (a phenolic acid), and polygalitol. It has xanthones.

POLYGALACEAE (Figure 135*a–f*).—Herbs, shrubs, and climbers, rarely small trees, saprophytes or parasites; xylem vessel perforation plates simple; interxylary phloem sometimes present; leaves alternate, rarely opposite or whorled, simple, entire, exstipulate or rarely stipulate; inflorescences axillary or terminal racemes, spikes or panicles, or the flower solitary; flowers bisexual, usually zygomorphic; sepals 5, free or rarely connate, the 2 inner ones usually

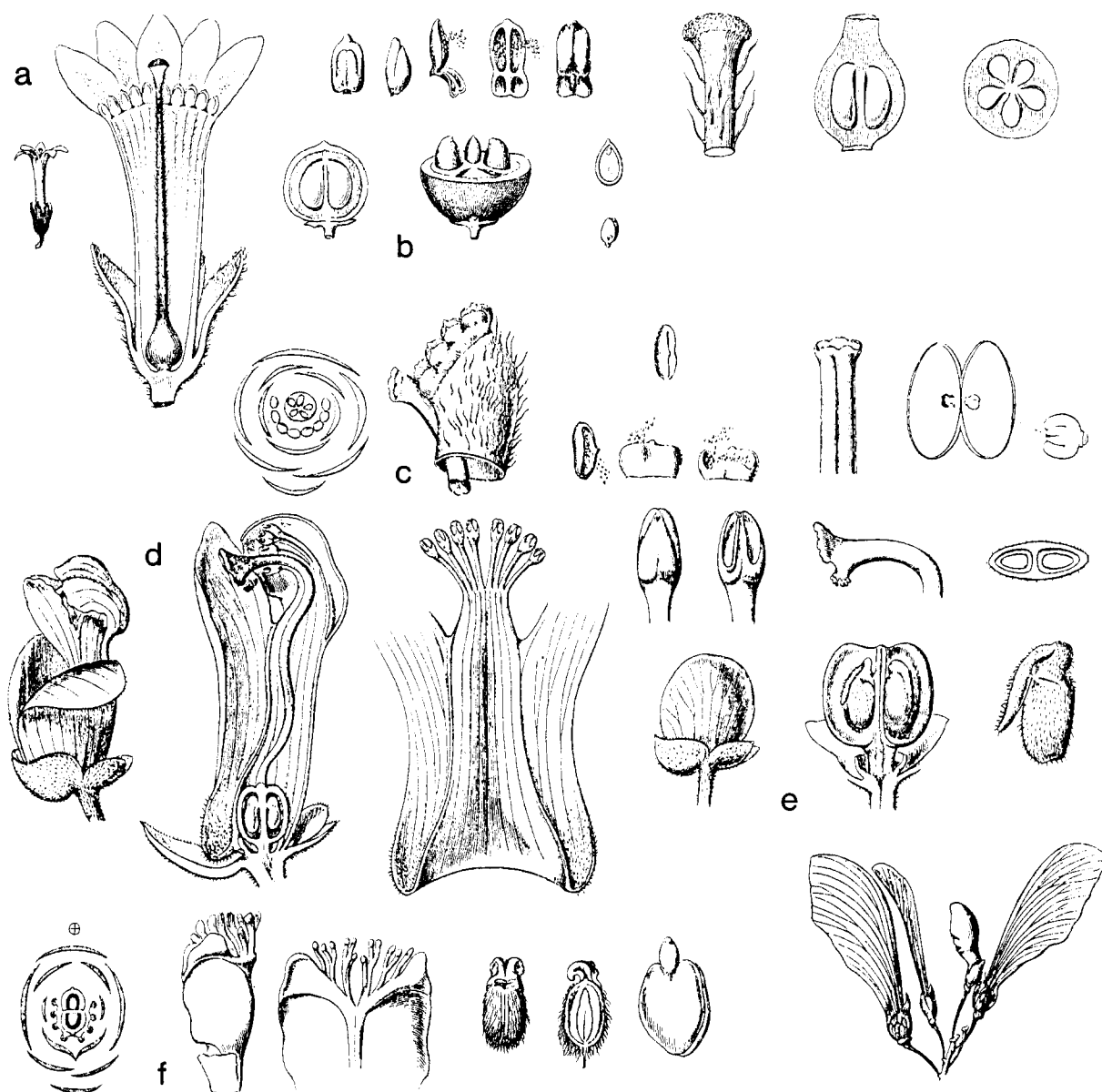


FIGURE 135.—POLYGALACEAE: *a*, *Diclidanthera penduliflora* flower, l.s. of same (enlarged), views of anther before and during dehiscence, upper part of style with stigma, l.s. and c.s. of ovary; *b*, *D. laurifolia* l.s. and c.s. of fruit, l.s. of seed, embryo; *c*, *Moutabea dibotrya* floral diagram, staminal tube and upper part of style within, views of anther, upper part of style and stigma, *M. aculeata* seed laid open, embryo; *d*, *Polygala ligustroides* flower, l.s. of same, androecium (adnate to petals) laid open, views of anther, apex of style with stigma, c.s. of ovary; *e*, fruit enclosed in persistent calyx, l.s. of fruit, immature seed with aril; *f*, *P. brasiliensis* floral diagram, *P. aphylla* 2 views of apex of anterior petal showing crest, *P. violacea* seed, l.s. same, embryo, *Securidaca lanceolata* fruits (after Martius, 1840–1906).

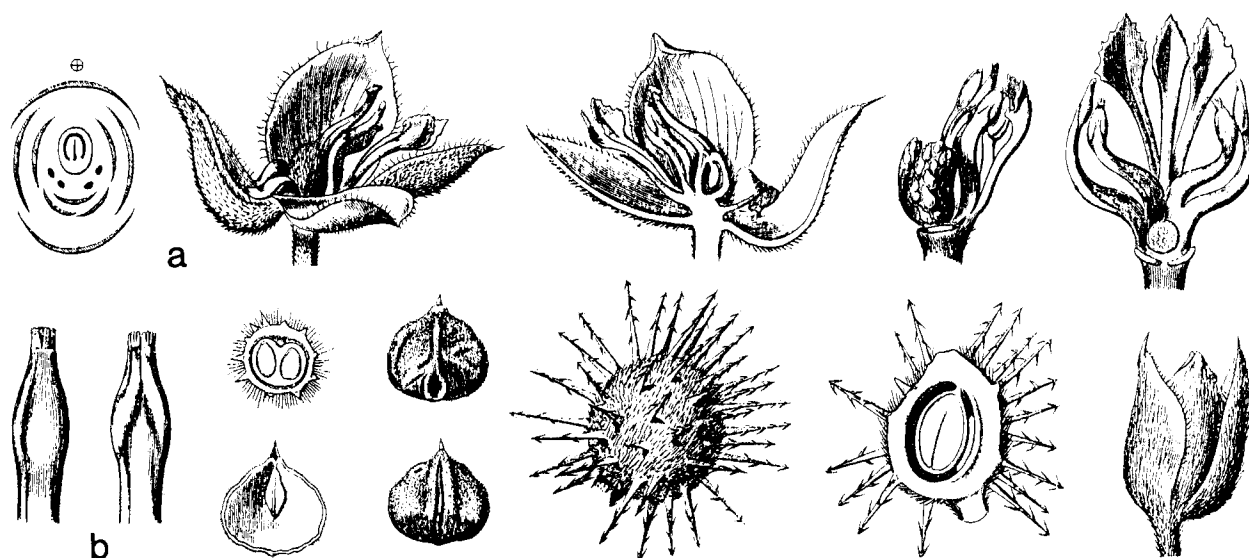


FIGURE 136.—KRAMERIACEAE: *a*, *Krameria tomentosa* floral diagram, flower, l.s. of same, androecium with petals from a bud, androecium and 3 petals; *b*, views of anther, c.s. of ovary and l.s. of seed, 2 views of seed, fruit, l.s. of same, *K. argentia* bud (after Martius, 1840–1906).

colored; petals 3–5, the outer 2 free or connate with the lowermost, the upper 2 free, sometimes minute and scale-like or absent; stamens 8 (3, 4, 5, 7, or 10 in 2 series), monadelphous or rarely free (*Xanthophyllum* spp.), the sheath split above, often adnate to the petals; anthers small, basifixed, dehiscent by an apical pore, rarely nearly to the base, or transversely (*Diclidanthera*); pollen polycolporate, the colpi 7–28; rarely an annular disk within the stamens (*Xanthophyllum*); pistil 1, the carpels 2 (3, 5), one of the 2 in *Monnina* usually rudimentary, style 1, stigma(s) apical; ovary superior, 2(1–5)-locular, the ovules 1 per locule, axile, or rarely 2–6 per placenta and parietal when the ovary is unilocular (*Xanthophyllum*), bitegmic, crassinucellar, anatropous or semi-anatropous; fruit usually a loculicidal capsule, sometimes a nut, drupe, berry or samara; seeds arillate (appendaged), often hairy; embryo straight, as long as the endosperm; cotyledons moderately or very thick and plano-convex (*Xanthophyllum*), 1.5–3.2 times wider than the radicle, 0.5–0.8 the length of the embryo, the radicle rarely invested (*Xanthophyllum*); endosperm copious, moderate or rarely 0.

Composition: 13 genera, ~900 species.

Distribution: Cosmopolitan except the arctic and cool temperate region of the Northern Hemisphere, New Zealand, and the central Pacific islands; centered in the American tropics and Africa.

KRAMERIACEAE (Figure 136*a,b*).—Shrubs and herbs; xylem vessel perforation plates simple; leaves alternate, simple, entire, exstipulate; inflorescences axillary or terminal racemes or the flowers solitary; flowers bisexual, zygomorphic; sepals 5 (4), free; petals 5, the 3 upper long-clawed, free or connate, the 2 lower usually much smaller, thick; stamens 4 (3), the filaments thick, free or adnate to the claws of the upper petals; anthers small, basifixed, dehiscent by a terminal pore; pollen 4-colporate (-ruporate); pistil 1, the carpels 2 (1 sterile), style 1, stigma apical, discoid; ovary superior, unilocular, the ovules 2, apical, bitegmic, anatropous; fruit a globose bristly achene; seed 1, the embryo straight, radicle invested; cotyledons broad and thick, 0.75 the length of the embryo; endosperm 0.

Composition: 1 genus, 20 species.

Distribution: Mainly dry regions; tropical and warm temperate America from southwestern United States to Argentina and Chile.

TRIGONIACEAE (Figure 137*a,b*).—Scandent shrubs or trees; xylem vessel perforation plates simple; intraxylary phloem absent; leaves opposite, rarely alternate, simple, entire, stipulate or exstipulate; inflorescences axillary and terminal racemes, panicles or thyrses, rarely 3-flowered cymes; flowers bisexual, zygomorphic; sepals 5, free or shortly connate; petals 5 or 3, free, the posterior one largest and gibbous or spurred, a gland often present opposite this petal; stamens 3–12, some staminodal, the filaments connate; anthers about as long as wide, dorsifixed, dehiscing longitudinally; pollen 3–4-porate or 3-colporate; 1–3 glands usually adjoining the split staminal tube; pistil 1, the carpels 3, style 1, stigma apical, capitate or not enlarged; ovary superior, 3- or 1-locular, the ovules 1 to ∞ per locule, axile, bitegmic, crassinucellar, anatropous; fruit a septicidal capsule, rarely a samara; seeds usually enveloped in long hair; embryo straight, 0.8–0.9 the length of the endosperm, cotyledons 5–7 times wider than the radicle, 0.8–0.85 the length of the embryo; endosperm scanty, fleshy.

Composition: 4 genera, 35 species.

Distribution: Lowland moist forest; tropical America, western Malaysia, Madagascar.

VOCHYSIACEAE (Figure 137*c,d*).—Large resinous trees, shrubs, and climbers; xylem vessel perforation plates simple; intraxylary and interxylary phloem sometimes present; leaves opposite or verticillate, rarely alternate, simple, entire, stipulate or exstipulate; inflorescences racemes, panicle or cymose; flowers bisexual, zygomorphic; sepals 5, shortly connate, one longer than the others and gibbous or spurred; petals 1–3 (5, 0), free; stamens 1 fertile, 1–4 staminodes, the filaments free; anthers about as long as wide, basifixed, rarely dorsifixed, sometimes apiculate, dehiscing longitudinally; pollen 3-colporate, occasionally rugoidate; pistil 1, the carpels 3, style 1, clavate, the stigma terminal or lateral; ovary superior or rarely adnate to the calyx, 1–3-locular, the ovules (1) 2 to ∞ per locule, axile, bitegmic, crassinucellar, anatropous or semi-anatropous; fruit a loculicidal capsule, rarely samaroid due to enlargement of sepals; seeds often

winged, sometimes pilose; embryo straight or the cotyledons folded or convolute, sometimes the radicle invested; cotyledons thin, 6–12 times wider than the radicle, 0.7–0.8 the length of the embryo; endosperm 0, rarely scanty (*Erismadelphus*).

Composition: 6 genera, 200 species.

Distribution: Almost entirely tropical America; one small genus in tropical western Africa.

OLEALES

Trees, shrubs, and lianas; xylem vessel perforation plates typically simple, rarely also scalariform with few bars; interxylary phloem rarely present; leaves opposite, very rarely alternate, simple or compound, entire or toothed, mostly exstipulate; flowers bisexual, rarely unisexual; sepals 4 (0–15), connate; petals 4 (0–15), connate, rarely free; stamens 2 (4, 5), free or inserted on the corolla, the filaments very rarely connate; anthers dorsifixed or basifixed, the loculi back to back; pollen 3(4)-colpate, -colporate, occasionally 4-rupate or 6-rugate; glandular disk sometimes present; pistil 1, the carpels 2, style 1, the stigmas apical; ovary superior, 2(1)-locular, the ovules 2 (1–10) per locule, axile (basal); fruit a loculicidal (circumscissile) capsule, berry, drupe, schizocarp or samara; embryo mostly long; endosperm copious to absent.

Distribution: Cosmopolitan, except cool regions, in mesic to dry habitats.

Chemistry: Gibbs considers it reasonable to make a separate order for the Oleaceae and to associate it closely with the Gentianales.

OLEACEAE (Figure 138*a,b*).—Trees, shrubs and lianas; xylem vessel perforation plates typically simple, rarely also some scalariform with 1 or more bars in 3 genera; leaves opposite, very rarely alternate (*Jasminum* spp.), simple or pinnately compound, entire or toothed, often with peltate trichomes, exstipulate; inflorescences terminal or axillary racemes, panicles or dichasia; flowers bisexual or rarely the plants dioecious or polygamodioecious; sepals 4 (0–15), connate; petals 4 (0–15), connate or rarely free (*Fraxinus* spp.), imbricate or induplicate valvate, rarely

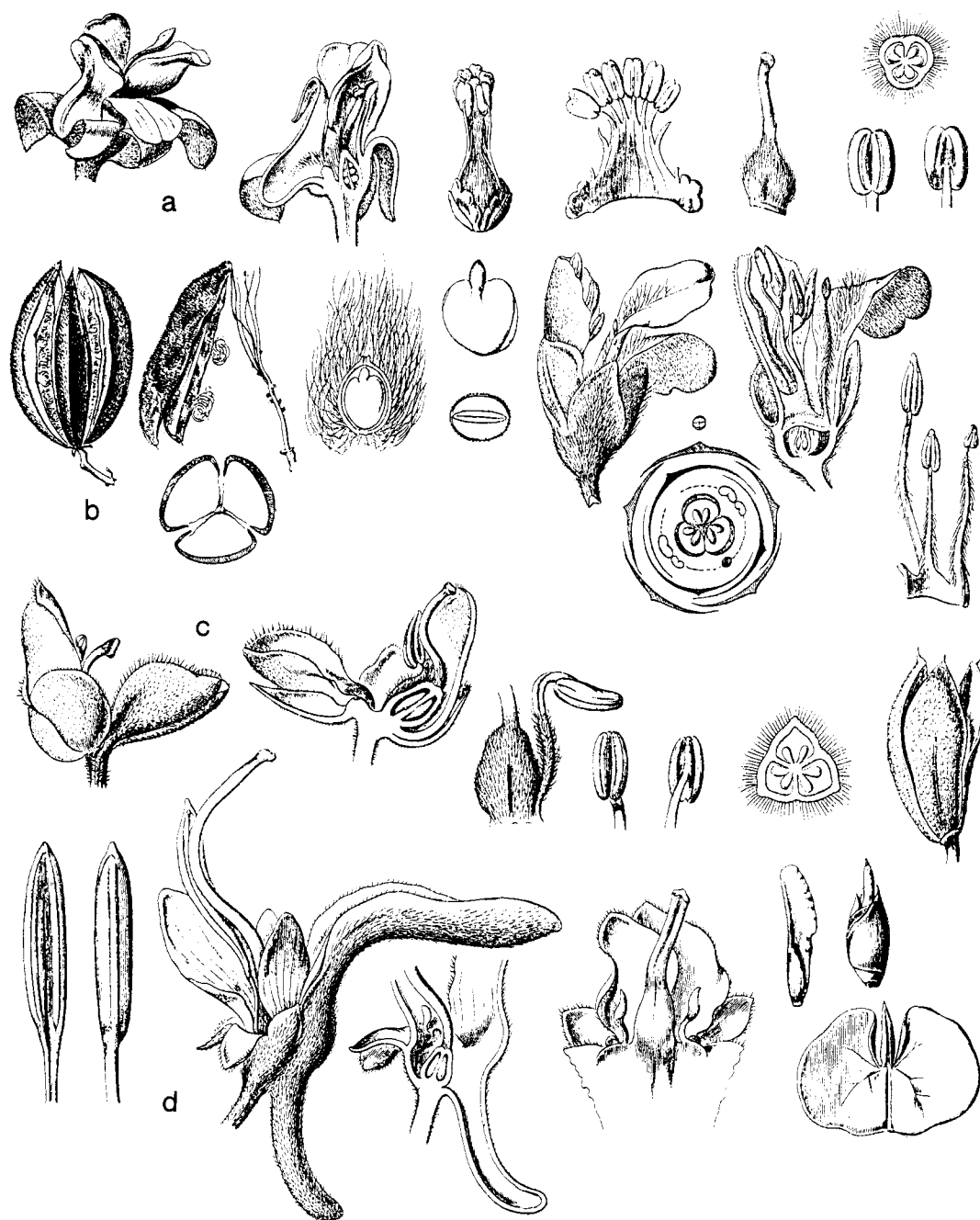


FIGURE 137.—TRIGONIACEAE: *a*, *Trigonia pubescens* flower, l.s. of same, essential organs, androecium laid open, pistil, c.s. of ovary and views of anther; *b*, dehiscent fruit, 1 valve of fruit showing exocarp, endocarp and seeds and c.s. of dehiscent fruit, l.s. of seed, embryo and c.s. of seed (hair removed), *Lightia licanoides* flower, l.s. of same, floral diagram, part of androecium (after Martius, 1840–1906). VOCHYSIACEAE: *c*, *Qualea cryptantha* flower, l.s. of same, ovary and stamen, views of anther, c.s. of ovary, dehiscent fruit; *d*, *Vochysia haenkeana* views of anther, flower, l.s. of base of same, base of stamen, staminodes and part of calyx, *V. obscura* seed, embryo with convolute cotyledons and laid open (after Martius, 1840–1906).

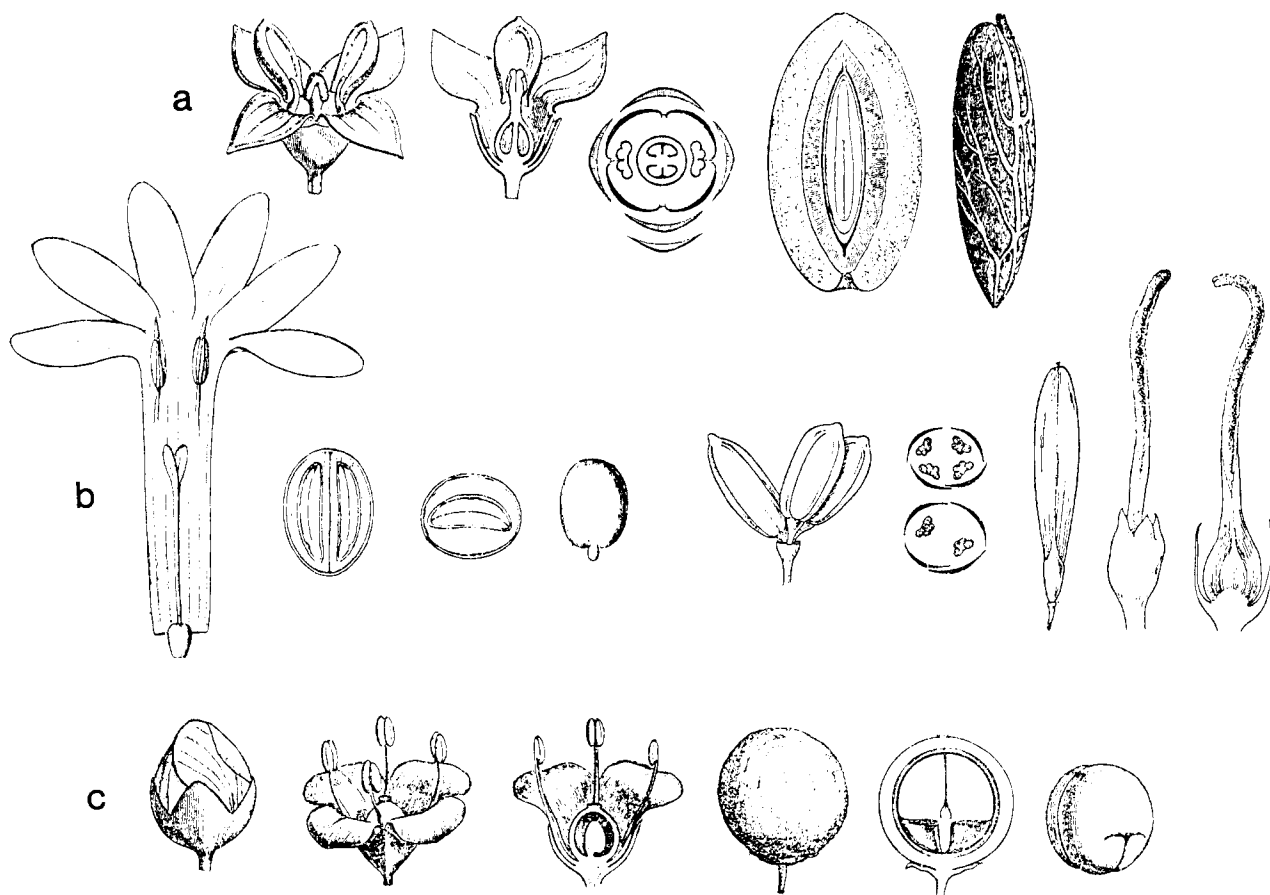


FIGURE 138.—OLEACEAE: *a*, *Olea europaea* flower, l.s. of same, floral diagram, l.s. of fruit, seed; *b*, *Jasminum azoricum* flower laid open, *J. officinale* l.s. of fruit, c.s. of seed, embryo, *Fraxinus* sp. ♂ flower, floral diagrams of ♂ flower with 2 and 4 stamens, fruit, ♀ flower, pistil and l.s. of calyx (after Baillon, 1866–1895; Martius, 1840–1906; Johnson). SALVADORACEAE: *c*, *Salvadora persica* bud, flower, l.s. of same, fruit, l.s. of same, embryo (after Baillon, 1866–1895).

convolute; stamens 2 (4 in *Hesperelaea* and *Tessarandra* and some species in a few other genera), free or inserted on the corolla alternate with the lobes; anther loculi back to back, dorsifixed or basifixed, the connective often produced apically; pollen usually 3(4)-colpate-colpor(oid)ate, occasionally 4-rupate; disk 0; pistil 1, the carpels 2, style 1, the stigmas apical; ovary superior, bilocular, the ovules 2 (1–10) per locule, axile, unitegmic, tenuinucellar, anatropous or amphitropous; fruit a loculicidal or circumscissile (*Mendodora*) capsule, berry, drupe, schizocarp or samara, the seeds 1–4; embryo straight, rarely contortuplicate (one species of *Schrebera*), 0.1 to as

long as the endosperm, mostly long, but may be minute before after-ripening in *Fraxinus*; cotyledons thin or moderately thick, 1.3–6.0 times wider than the radicle, 0.5–0.86 the length of the embryo; endosperm copious, moderate or 0, fleshy.

Composition: 28 genera, 600 species.

Distribution: Cosmopolitan except the arctic and cool temperate regions of the Northern Hemisphere, cool temperate South America and New Zealand; centered in southeastern Asia and the East Indies.

SALVADORACEAE (Figure 138c).—Trees and shrubs; xylem vessel perforation plates simple;

interxylary phloem in 2 of the 3 genera; leaves opposite, simple, entire, small stipules sometimes present; inflorescences axillary and terminal spikes, racemes, panicles or fascicles; flowers bisexual or the plants dioecious; sepals 3–4 (2–5), connate; petals 4 (5), free or basally connate, imbricate; stamens 4 (5), hypogynous or inserted on the base of and alternate with the petals, the filaments free or basally connate; anther loculi back to back; pollen 3-colporoidate, exceptionally 4-rupate or 6-rug(oroid)ate; disk 0 or consisting of separate glands between the filaments; pistil 1, the carpels 2, style 1, short, the stigma(s) apical; ovary superior, 1–2-locular, the ovules 1–2 per locule, basal, bitegmic, crassinucellar, anatropous; fruit a berry or drupe, the seeds mostly 1; cotyledons thick, plano-convex, 4 times wider than the radicle, 0.8–0.9 the length of the embryo; endosperm 0.

Composition: 3 genera, 12 species.

Distribution: Dry, often saline habitats; Africa except the west-central region; Madagascar; Arabia to India, southern China, and the western East Indies.

GENTIANALES

Trees, shrubs, and herbs, sometimes climbing, rarely saprophytic or parasitic and chlorophyllless, often bitter; xylem vessel perforation plates usually simple, rarely scalariform or both; intraxylary or interxylary phloem sometimes present; laticiferous canals sometimes present; leaves opposite, rarely alternate or whorled, simple, very rarely compound, entire or very rarely toothed, lobed or dissected, stipulate or exstipulate; flowers bisexual, rarely unisexual, actinomorphic, very rarely zygomorphic; sepals 5–4 (2–12), connate or free, sometimes with basal nectar glands; petals 4–5 (3–16), connate, sometimes with a corona, very rarely spurred; stamens 4–5 (1–16), the filaments free or connate, very rarely strongly unequal, inserted on the corolla, very rarely hypogynous or nearly epigynous, alternipetalous, the anthers rarely sessile, basifixed or dorsifixed, rarely connate; pollen 2-polycolpate,

2-multicolpate, 3–4(1–6)-porate, rarely polyforate, 4-rupate or ruplicate, 6-rugate or nonaperturate; pollen grains single or sometimes in tetrads, masses or pollinia; glandular disk usually present; pistil 1, the carpels 2 (3–9), style 1 (2), sometimes 2–4-lobed, the stigma(s) apical or ventral; ovary superior to inferior, 2(1–9)-locular, the locules rarely separate; ovules 1—many per locule, axile or parietal, rarely basal or apical, unitegmic; fruit a septicidal, loculicidal or rarely circumscissile capsule, berry, drupe, schizocarp or follicles, rarely a nut or samara; seeds sometimes with a coma or hairy; embryo straight or folded, minute to large; endosperm copious to absent.

Distribution: Cosmopolitan, most common in the tropics and subtropics, in various habitats.

Chemistry: Alkaloids in great variety occur in the order. The oxindole alkaloids seem to be confined to Gentianales—Loganiaceae, Apocynaceae, Rubiaceae; several others are confined to this order. Gibbs knows nothing that sets the Loganiaceae or Desfontainiaceae apart; likewise with Gentianaceae and Menyanthaceae, both have gentianine, but differ in some respects, enough to segregate them he feels. Apocynaceae and Asclepiadaceae are very closely related. By and large the chemistry of Rubiaceae supports its inclusion here, but there are differences that set it apart fairly clearly. Loganin occurs in *Mastixia* (Cornaceae). The emetine group occurs in Rubiaceae, Alangiaceae, and Icacinaceae. The Convolvulaceae is the only family in “Tubiflorae” with ergoline alkaloids.

LOGANIACEAE (Figure 139a–d).—Trees, shrubs, and herbs, sometimes climbers or epiphytes; xylem vessel perforation plates usually simple, rarely scalariform or both; intraxylary or interxylary phloem present; leaves opposite, rarely verticillate, simple, entire, bitter, stipulate or exstipulate; inflorescences terminal and axillary cymes, spikes, racemes, panicles, heads or rarely the flowers solitary; flowers bisexual, very rarely polygamo-dioecious, actinomorphic or very rarely not so in calyx, corolla or androecium; sepals 5–4, connate or free, rarely bipar-



FIGURE 139.—LOGANIACEAE: *a*, *Antonia ovata* l.s. of bud, flower, corolla laid open, views of stamen, pistil, ovary, 2 views of stigma and 3 views of seed, 2 fruits, dehiscent fruit, l.s. of fruit; *b*, *Strychnos breviflora* cyme, corolla laid open to show insertion of stamens, calyx laid open, views of stamen, c.s. of ovary; *c*, fruit and leaf, *S. brasiliensis* pistil, stigma and style, c.s. of ovary at 3 levels, c.s. and l.s. of seed, embryo; *d*, *Desfontainea spinosa* corolla laid open, pistil and part of calyx, c.s. of ovary, fruit (after Martius, 1840–1906; Hooker and Hooker, 1837–1982). PLOCOSPERMATACEAE: *e*, *Plocosperma buxifolium* flower, same laid open; *f*, pistil, l.s. of ovary, dehiscent fruit showing the solitary seed with a tuft of hairs (after Bentham).

tite, the lobes imbricate, very rarely 1 enlarged and petaloid (*Usteria*); petals 4–5 (–16), connate, the lobes imbricate, contorted or valvate; a corona present in *Scyphostrichnos*; stamens 4–5 (–16), very rarely 1 (*Usteria*), the filaments all similar, free or connate, inserted on the corolla, or rarely hypogynous, alternate with the lobes, rarely the anthers sessile; anthers usually elongated, dorsifixed or rarely basifixed, subconnate in *Gardneria*; pollen 3(2–4)-colpate, 3(4)-colporate, 3–4(–6)-porate, or 4-ruporate; disk present or absent; pistil 1, the carpels 2 (3–5), style 1 (2 in *Cynoctonum*), the stigma(s) apical, sometimes capitate or clavate; ovary superior or rarely semi-inferior (*Mitreola*), 2(1–5)-locular, rarely 2 separate ovaries but 1 style (*Mitreola*), the ovules generally numerous, but 1 per locule in 1–2 genera, mostly axile, sometimes parietal, rarely basal, unitegmic, tenuinucellar, anatropous, amphitropous, or semi-anatropous; fruit a mostly septicidal, sometimes also partially loculicidal or rarely circumscissile capsule, sometimes a berry or drupe, attachment of the seeds sometimes peltate; seeds sometimes minute; embryo straight, rarely curved, 0.3 to as long as the endosperm; cotyledons thin, 1–2.7 times the width of the radicle, 0.1–0.7 the length of the embryo; endosperm copious or moderate, fleshy to bony.

Composition: ~20 genera, ~500 species.

Distribution: Usually in dry, lowland habitats; pantropical, few species temperate.

PLOCOSPERMATACEAE (Figure 139*e,f*).—Shrubs and trees; leaves opposite or subverticillate, simple, entire, exstipulate; inflorescences axillary, with 1–4 flowers; flowers bisexual, actinomorphic; sepals 5 (6), connate; petals 5 (6), connate, imbricate; stamens 5 (6), inserted on the corolla, alternipetalous, the filaments elongated; anthers dorsifixed, about as long as wide; pollen 3-colporate; disk small; pistil 1, the carpels 2, style 1, twice shortly bilobed apically, the stigmas 4, clavate; ovary superior, unilocular, the placentas 2, one subapical the other subbasal, the ovules 2 per placenta; fruit an elongated bivalved capsule; seeds 1.2–2.3 cm. long, mostly 1, terete,

with an apical tuft of hairs; embryo linear, straight; endosperm scanty, fleshy.

Composition: 1 genus, 3 species.

Distribution: Mexico, Central America.

APOCYNACEAE (Figure 140*a–e*).—Lianas, rarely trees, shrubs, and herbs; xylem vessel perforation plates simple, very rarely also scalariform; laticiferous canals and intraxylary phloem present; leaves opposite or verticillate, rarely alternate, simple, entire, exstipulate or rarely with small interpetiolar stipules; inflorescences paniculate, often with cymose partial inflorescences, dichasial cymes or cincinni, or the flowers solitary; flowers bisexual, actinomorphic; sepals 5 (4), connate, often glandular basally inside; petals 5 (4), connate, contorted, imbricate, rarely valvate, sometimes with coronal appendages on the corolla; stamens 5 (4), inserted on the corolla, alternipetalous, the filaments short or rarely 0, free or rarely connate, not appendaged; anthers basifixed or basally dorsifixed, usually sagittate, connivent around the stigma, rarely connate, the connective often produced apically; pollen granular, rarely in tetrads, 3(–5)-colporate or 2–3(4)-porate; disk usually present around the base of the ovary, annular, cupular or of separate glands; pistil 1, the carpels 2 (3–5), style 1, the stigmas apical; ovaries often 2, superior or semi-inferior, the locules 1 or 2, the placentas axile in a bilocular ovary, parietal in a unilocular ovary, the ovules 1 or more per placenta, unitegmic, tenuinucellar, ± anatropous; fruit 2 (1) follicles, berry, drupe, septicidal capsule or schizocarp, the seeds often with apical and basal tufts of hairs, sometimes winged, or arillate (*Tabernaemontaneae*); embryo straight or the radicle rarely recurved, 0.4 to as long as the endosperm; cotyledons thick or thin, sometimes convolute, 1–3.3 times the width of the radicle, 0.4–0.6 the length of the embryo; endosperm copious, sometimes ruminate, scanty or 0, fleshy, sometimes firm.

Composition: ~180 genera, ~1500 species.

Distribution: Pantropical, few species temperate.

ASCLEPIADACEAE (Figure 141*a–c*).—Lianas, shrubs, herbs, or rarely small trees; xylem vessel

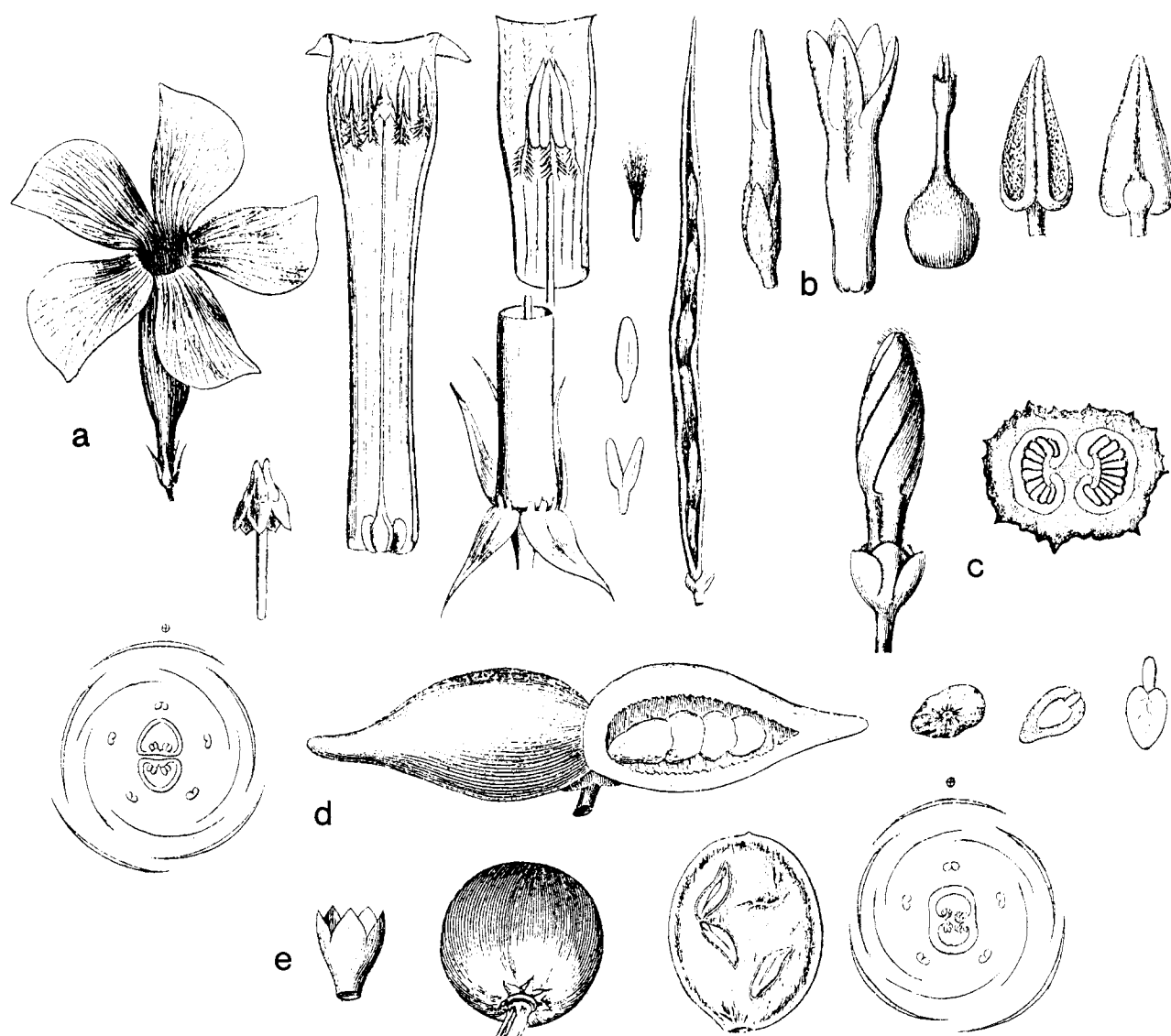


FIGURE 140.—APOCYNACEAE: *a*, *Dipladenia gentianoides* flower, *D. polymorpha* stigma, corolla laid open to show pistil and stamens, upper part of corolla opened and showing normal position of anthers and style, lower part of corolla tube and calyx (below), seed, embryo and same opened, dehiscent fruit; *b*, *Aspidosperma subincanum* bud, corolla, pistil, views of anther; *c*, *Tabernaemontana reticulata* bud, *Ambelania tenuiflora* c.s. of ovary; *d*, *Geissospermum vellosii* floral diagram, fruitlets, one in l.s., seed, embryo and endosperm, embryo; *e*, *Hancornia speciosa* calyx, fruit, l.s. of same, floral diagram (after Martius, 1840–1906).

perforation plates simple; laticiferous canals and intraxylary phloem present; leaves opposite or verticillate; rarely alternate (*Asclepias* spp.), simple, entire, very rarely lobed or dentate, exstipulate; inflorescences terminal or at leaf nodes,

mostly cymose, often umbelliform; flowers bisexual, sometimes the plants functionally dioecious in Periplocoideae, actinomorphic; sepals 5, connate or free; petals 5, connate, the lobes contorted, imbricate or valvate; stamens 5, inserted

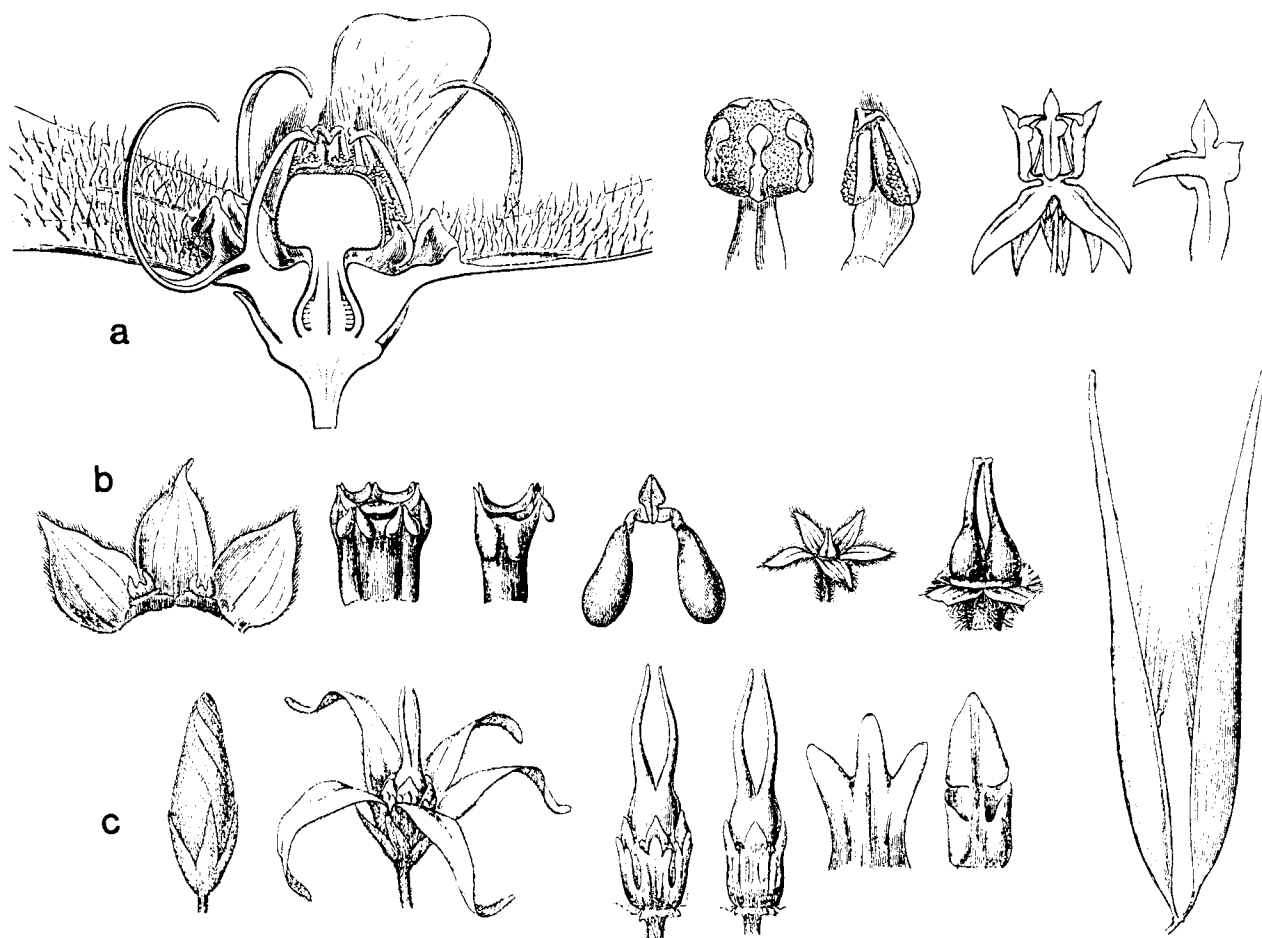


FIGURE 141.—ASCLEPIADACEAE: *a*, *Periploca graeca* l.s. of flower, summit of style, stamen, *Asclepias candida* flower, corona segment; *b*, *Phaeostemma riedelii* part of corolla and corona laid open, androecium, stamen, pollinia, calyx and pistil, pistil; *c*, *Oxypetalum guilleminianum* bud, flower, pistil surrounded by stamens and corona, same with corona removed, single segment of corona, stamen, *Jobinia hernandifolia* dehiscent fruit (after Martius, 1840–1906; Baillon, 1866–1895).

on the corolla, alternipetalous, the filaments connate (free in *Periploca*), short, with a nectariferous coronoid appendage, the corona rarely absent; anthers basifixed, connivent or connate above the stigma, acute or acuminate apically; pollen usually in pollinia (in masses of 20 in Secamoneae, granular or in masses in Periplocoideae, 3–6-aperturate in the latter; disk absent; pistil 1, the carpels 2, united by the stigma; ovaries 2, superior, very rarely semi-inferior (*Atherandra*), the placentas ventral, the ovules usually numerous, unitegmic, the integument rather

thick, pseudocrassinucellar or \pm tenuinucellar, anatropous; fruit 2 (1) follicles, the seeds usually compressed, mostly with an apical coma; embryo straight, 0.8–0.9 the length of the endosperm; cotyledons thin, 3–4.5 times wider than the radicle, 0.6–0.7 the length of the embryo; endosperm moderate, firm-fleshy.

Composition: ~200 genera, ~2,000 species.

Distribution: Often in dry habitats; tropical and subtropical, centered in south Africa and secondarily in South America, few species in temperate zones.

CONVOLVULACEAE (Figure 142a-c).—Lianas, herbs, shrubs, rarely small trees; xylem vessel perforation plates simple; laticiferous canals usually present; intraxylary phloem present; leaves alternate, simple, entire, lobed or subcompound, sometimes with extrafloral nectaries on the petiole, exstipulate; inflorescences axillary dichasia, cincinni or bostryx, rarely umbelliform or thyrses, rarely terminal racemes or panicles (*Porana*), or the flowers solitary; flowers bisexual, rarely the plants dioecious (*Hildebrandtia*), actinomorphic, rarely zygomorphic (*Humbertia*); sepals 5 (4), usually free and markedly imbricate, rarely connate (*Wilsonia*); petals 5 (4), connate, plicate-contorted, the lobes rarely imbricate; stamens 5 (4), inserted on the corolla toward its base, alternipetalous, the filaments elongated, the anthers usually elongated, basifixed; pollen (2)3-colpate (sometimes colpate?), polyforate, or polyrugate; disk annular, mostly lobed, surrounding the base of the ovary; pistil 1, the carpels 2 (3–5), styles 1 (0 in *Erycibe*, 2 in *Cressa*), the stigmas 2 (–8), elongated or globose; ovary superior 2(1–5)-locular, sometimes deeply bilobed (*Dichondra*), the ovules usually 1 or 2 per locule (∞ in *Humbertia*), axile and subbasal, unitegmic, tenuinucellar or crassinucellar, anatropous; fruit a loculicidal capsule, rarely a berry, nut, or schizocarp of 1, 2, or 4 one-seeded mericarps, or samaroid; embryo usually folded (linear in *Nephrophyllum*), 2–3 times longer than the endosperm(?); cotyledons thin 1–9 times wider than the radicle, 0.6–0.9 the length of the embryo; endosperm moderate or scanty, hard and clear or semitransparent.

Composition: 50 genera, ~1700 species.

Distribution: Various habitats, cosmopolitan except the arctic and cool temperate regions of the Northern Hemisphere; centered in tropical America and Asia, few in temperate zones.

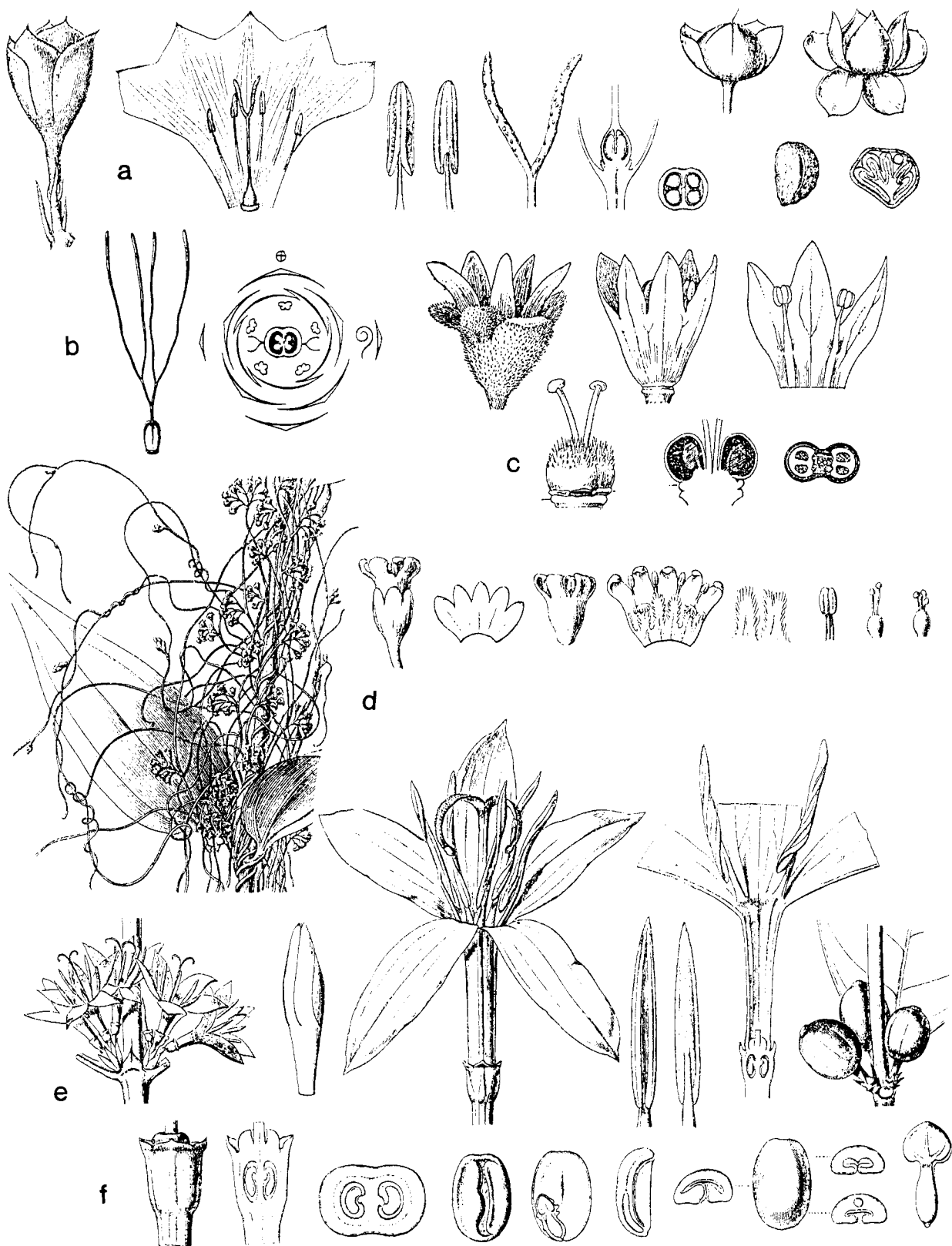
CUSCUTACEAE (Figure 142d).—Parasitic chlorophyllless yellow or orange twining herbs; xylem vessel perforation plates simple; leaves 0; inflorescences fascicles; flowers bisexual; sepals 5 (4), free or connate; petals 5 (4), connate, the lobes imbricate; coronal scales alternate with the sta-

mens; stamens 5 (4), inserted on the corolla, alternipetalous; anthers small, basifixed?, the connective sometimes produced apically; pollen 3–4-colpate, 6-rugate or 4-rupate; pistil 1, the carpels 2, styles 2 (1); ovary superior, completely or incompletely bilocular, the ovules 2 per locule, axile, unitegmic, tenuinucellar, anatropous; fruit a capsule, dehiscing transversally or irregularly, or berry-like; embryo linear, terete, curved or spirally twisted, 2–3 times longer than the endosperm?; cotyledons as wide as the radicle, 0.6 the length of the embryo or less; endosperm hard, moderate.

Composition: 1 genus, 170 species.

Distribution: Nearly cosmopolitan, most abundant in America, especially warmer regions.

RUBIACEAE (Figure 142e,f).—Trees, shrubs, herbs, lianas; xylem vessel perforation plates simple, in several genera rarely also scalariform, usually with few bars; leaves opposite, rarely verticillate (*Henriquesia*), simple, entire or rarely toothed, very rarely sinuate-lobate or pinnatifid, stipulate, the stipules often interpetiolar; inflorescences terminal and axillary cymose panicles, heads, or small dichasia or rarely the flowers solitary; flowers bisexual, or rarely the plants dioecious or monoecious, actinomorphic or very rarely zygomorphic; calyx lobes (3) 4–5, often very small, sometimes one enlarged and petaloid; petals 4–5 (3–10), connate, the lobes contorted, imbricate or valvate, the corolla very rarely bilabiate, very rarely partite nearly to the base; stamens 4–5 (3–12), inserted on the corolla, alternipetalous, nearly epigynous in *Synaptantha* and a few other genera, the filaments very rarely connate, very rarely strongly unequal; anthers basifixed or dorsifixed, usually elongated, very rarely connate, the connective very rarely produced apically; pollen 3-polyporate, 2–4-multicolpate, 3-porate, exceptionally polyforate or nonaperturate; disk epigynous, surrounding the base of the style; pistil 1, the carpels 2 (3–9), style 1 (0 in *Tetralopha*), with 2 (3–4) linear or short apical lobes stigmatic on the ventral surface or 1 and capitate; ovary inferior (superior in *Gaertnera* and *Pagamea*, semi-inferior in *Synaptantha*



and *Henriquezia*), bilocular, rarely unilocular or 4–9 locules, the ovules 1 to ∞ per locule, mostly axile, sometimes apical or basal, rarely parietal (*Gardenia*), 1-tegmic (0 in *Houstonia*), the integument massive or thin, crassinucellar or tenuinucellar, anatropous or semi-anatropous; fruit a septicidal or loculicidal, rarely circumscissile capsule, berry, drupe, schizocarp (*Galium*), the seeds many to 1, rarely minute, very rarely arillate or the apex comose; embryo straight, rarely involute, 0.2 to as long as the endosperm; cotyledons thick or thin, 1–4 times the width of the radicle, 0.1–0.9 the length of the embryo; endosperm copious, scanty or 0, soft- to hard-fleshy, rarely ruminant or cartilaginous.

Composition: ~500 genera, ~6500 species.

Distribution: Cosmopolitan except arctic Northern Hemisphere; concentrated in the tropics and subtropics of the Eastern and Western Hemispheres.

COLUMELLIACEAE (Figure 143a).—Shrubs and small trees, bitter in all their parts, the wood very hard; xylem vessel perforation plates scalariform; leaves opposite, simple, entire or serrate, exstipulate; inflorescences terminal and axillary cymes; flowers bisexual, slightly zygomorphic; sepals 5, free above the ovary; petals 5, connate, imbricate in bud; stamens 2, the filaments very short, inserted on the corolla, alternipetalous; anthers unilocular, twisted, the connective broad; pollen 3-colporate; disk 0; pistil 1, the carpels 2, the

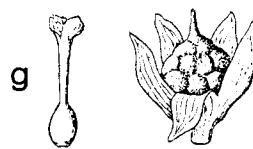
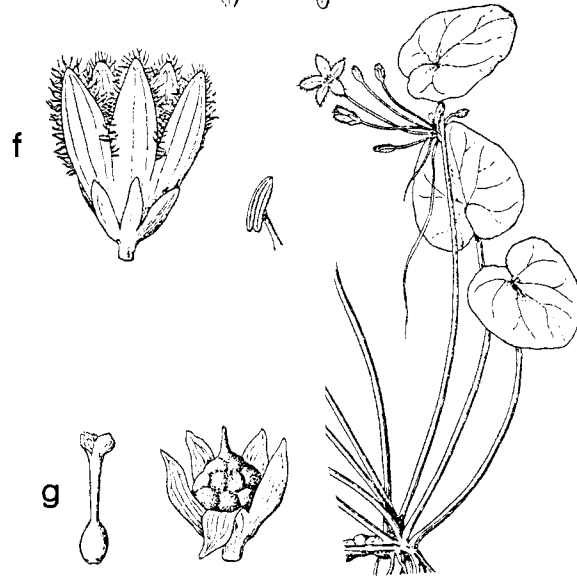
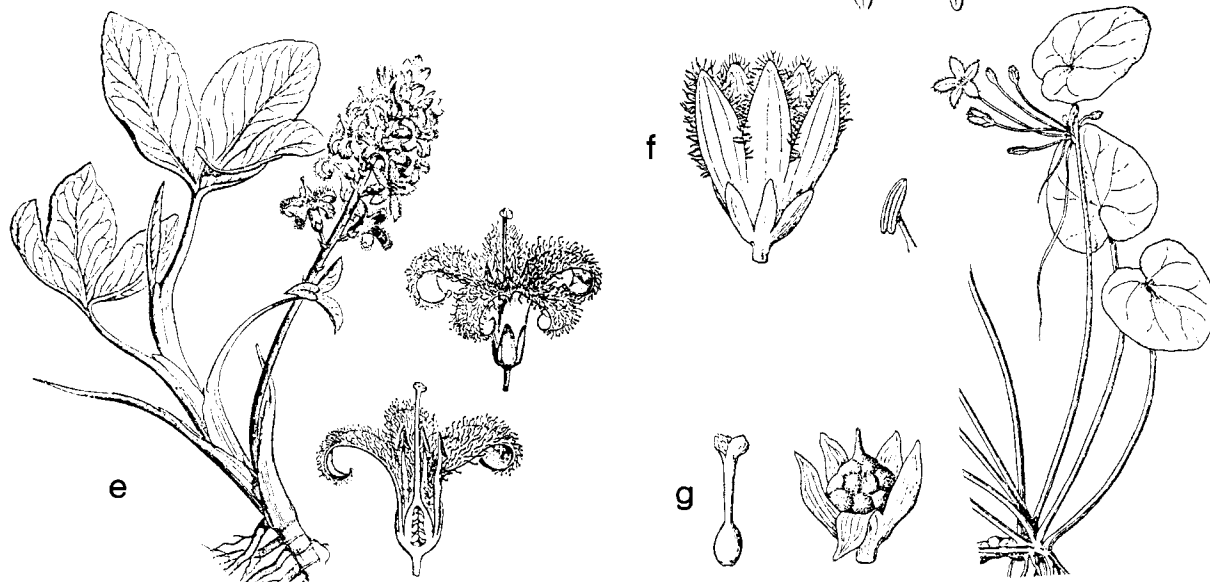
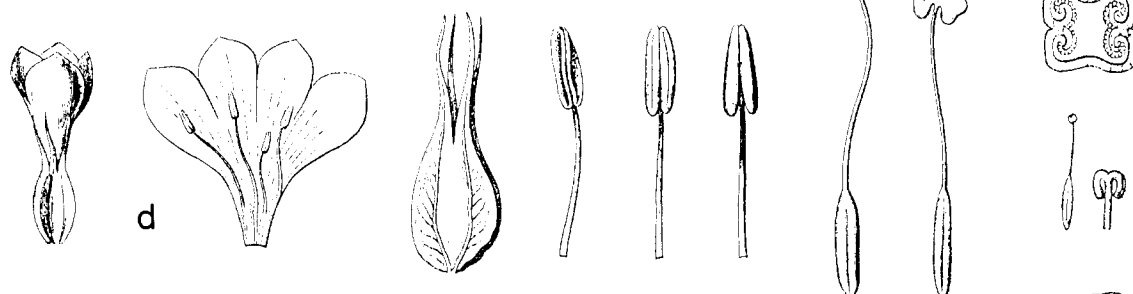
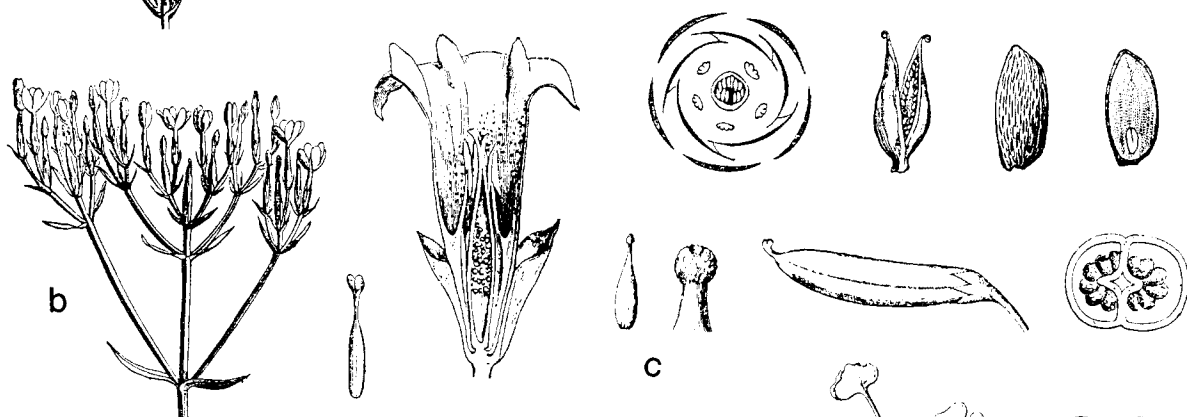
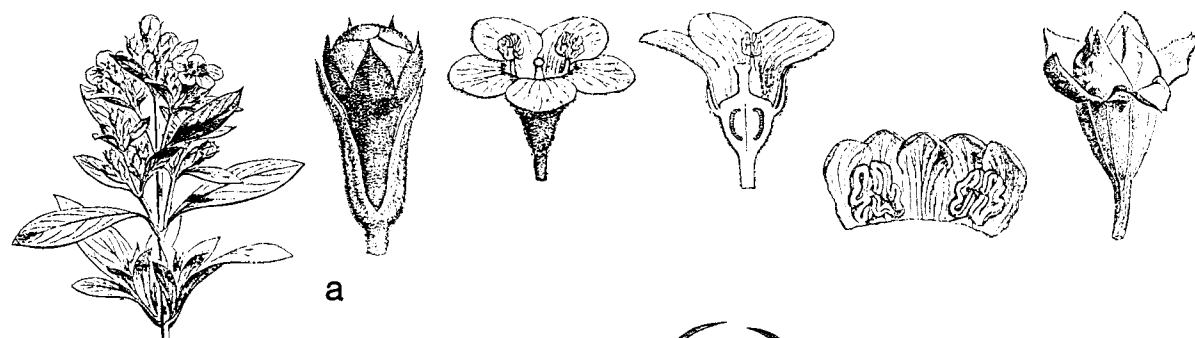
stigma broad, 2–4-lobed; ovary inferior, imperfectly bilocular, placentas 2, parietal, the ovules numerous; fruit a septicidal capsule, the seeds numerous, smooth; embryo minute, straight, 0.2 the length of the endosperm; cotyledons as wide as the radicle, 0.4 the length of the embryo; endosperm copious, fleshy.

Composition: 1 genus, 4 species.

Distribution: Andes from Colombia to Bolivia, at \pm 2000–3000 m. elevation.

GENTIANACEAE (Figure 143b–d).—Herbs, rarely saprophytic, very rarely shrubs; xylem vessel perforation plates simple; intraxylar phloem present; leaves opposite, rarely alternate (*Swertia* spp.), rarely verticillate, simple, entire, exstipulate; inflorescences usually terminal and axillary dichasia, sometimes monochasia or other type of cyme, or the flowers solitary; flowers actinomorphic, however the stamens rarely declinate, bisexual or the plants rarely polygamous; sepals 4–5 (2–12), connate, sometimes with basal nectar glands; petals 4–5 (–12), connate, contorted or very rarely imbricate, rarely with coronal scales, rarely spurred; stamens 4–5 (–12), rarely some staminodal (only 1 fertile in *Hoppea*), inserted on the corolla, alternipetalous, sometimes 2 nectaries on each corolla segment; anthers elongated, basifixed or dorsifixed near the base, longitudinally dehiscent or poricidal, occasionally connate (*Voyria*, *Leiphaimos* spp. and others), rarely with 1–4 apical or basal glands, the connective rarely produced apically; pollen rarely in polyads, usually 3(2–4)-colporate, exceptionally 4-ruporate or 6-rugorate, 1–3-porate in the saprophytic genera; disk annular or of 5 hypogynous glands, rarely absent; pistil 1, the carpels 2, style 1, bifid apically and the stigmas linear, or not divided and the stigma capitate; ovary superior, mostly unilocular, sometimes bilocular, the ovules numerous, mostly parietal, sometimes axile, unitegmic, tenuinucellar, anatropous or rarely \pm orthotropous; fruit a septicidal capsule, very rarely like a lantern, rarely a berry; seeds minute, numerous; embryo subglobular, linear or spatulate, 0.2–0.9 the length of the endosperm; cotyledons 1–2 times the width of the radicle,

FIGURE 142.—CONVOLVULACEAE: a, *Convolvulus ottonis* calyx, flower laid open, views of anther, stigmas with pollen grains attached, l.s. and c.s. of ovary, fruit with part of calyx, dehiscent fruit and calyx, seed, c.s. of same showing the folded cotyledons; b, *Evolvulus maximilianii* pistil, floral diagram, *Dichondra argentea* flower, corolla, part of corolla laid open; c, pistil and hypogynous glands, l.s. and c.s. of ovary (after Martius, 1840–1906; Johnson). CUSCUTACEAE: d, *Cuscuta racemosa* flowering shoot attached to host, flower, calyx laid open, corolla, same laid open showing appendages, 2 appendages, stamen, pistils (after Martius, 1840–1906). RUBIACEAE: e, *Coffea arabica* inflorescence, corolla in bud, flower, views of anther, l.s. of flower (style and part of corolla removed), fruits; f, ovary, l.s. and c.s. of same, seed, same opened to show embryo, l.s. of seed, seed and c.s. at 3 levels, embryo (after Martius, 1840–1906).



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0.1–0.5 the length of the embryo; endosperm copious, fleshy.

Composition: 80 genera, ~1000 species.

Distribution: Various habitats; cosmopolitan, most common in temperate regions and in mountains in the tropics.

MENYANTHACEAE (Figure 143*e–g*).—Aquatic and marsh herbs; xylem vessel perforation plates simple or scalariform; intraxylar phloem absent; leaves alternate and radical, sometimes opposite under the flower, simple or compound, entire or toothed, exstipulate; inflorescence a raceme, panicle, cyme, fascicle, head, or the flowers solitary or paired; flowers bisexual, actinomorphic; sepals 5, free or connate; petals 5, connate, induplicate valvate, rarely slightly imbricate in bud; stamens 5, inserted on the corolla, alternipetalous; anthers mostly sagittate, dorsifixed?; pollen 3-colporate, exceptionally 6-rugate; hypogynous nectaries usually present; pistil 1, the carpels 2, style 1, shortly bifid apically, the stigmas 2; ovary superior or semi-inferior, unilocular, the ovules numerous, parietal, unitegmic, tenuinucellar, anatropous; fruit a capsule, dehiscent by 2 or 4 valves or irregularly, rarely a berry; seeds numerous to few; embryo linear, straight, 0.5–0.75 as long as the endosperm; cotyledons as wide as the radicle, 0.3 the length of the embryo; endosperm copious, fleshy.

Composition: 5 genera, 40 species.

Distribution: Almost cosmopolitan.

FIGURE 143.—COLUMELLIACEAE: *a*, *Columellia oblonga* flowering shoot, bud, flower, l.s. of same, corolla laid open showing insertion of stamens, dehiscent fruit (after Baillon, 1866–1895). GENTIANACEAE: *b*, *Centaurium* sp. inflorescence, pistil, *Gentiana acaulis* l.s. of flower, floral diagram, dehiscent fruit, seed, l.s. of same showing the small embryo; *c*, *Tapeinostemon spenneroides* pistil, stigma, fruit, c.s. of same; *d*, *Schultesia angustifolia* flower, corolla laid open, calyx, views of stamen, views of pistil, c.s. of ovary, *S. doniana* pistil, stigmas (below) (after Le Maout and Decaisne, 1873; Martius, 1840–1906). MENYANTHACEAE: *e*, *Menyanthes trifoliata* flowering shoot, flower, l.s. of same; *f*, *Nymphoides indica* flower, stamen; *g*, pistil, fruit, flowering shoot (after Baillon, 1866–1895; Cabrera, 1965).

SANTALALES

Trees, shrubs, and herbs, sometimes climbing, usually parasitic on roots and stems but containing chlorophyll; xylem vessel perforation plates scalariform, usually with fewer than 20 bars, simple, or both; secretory canals and intraxylary or extraxylary phloem sometimes present; leaves alternate or opposite, simple, usually entire, sometimes crenate, rarely lobed or reduced to scales, exstipulate, rarely stipulate; flowers bisexual or unisexual; sepals 3–6 (–8, 0), usually minute and connate, rarely accrescent; petals 0, 3–6 (–8), free or connate; stamens 3–6 (1–20) in 1 or 2 series; staminodes sometimes present; filaments free or connate, hypogynous, epigynous or inserted on the corolla or calyx, the anthers basifixed or dorsifixed; pollen 3(2–4)-colpate, 3-colporoidate, 3–4(5)-porate, 4–12-forate; glandular disk present or absent; pistil 1, the carpels 2–5 (1), style 1 (2–4), usually short, the stigma(s) apical, less commonly decurrent ventrally, sometimes sessile; ovary superior to inferior, 1(–5)-locular, the multilocular ovary usually unilocular at apex, the ovules not developed before fertilization or 1–3 (–8), 0–2-tegmic, axile, or from the apex of a free-central placenta, or basal; fruit a drupe, berry, or nutlet, rarely a samara, achene or coriaceous capsule; seed 1, the embryo usually minute or small, straight, sometimes poorly differentiated, the cotyledons sometimes 3–6 or 0; endosperm usually copious, oily, sometimes absent.

Distribution: Cosmopolitan, especially pantropical and -subtropical, extending into temperate regions, in wet and dry habitats.

Chemistry: Aucubin (iridoid) glycoside is absent. Gibbs says we have difficulty defining the order and its families from their chemistry. The somatic lipids of Olacaceae, Opiliaceae, Santalaceae, and Loranthaceae have similar acetylenic acids, lending strong support to the idea that these families are closely related. The seed fats of Olacaceae and Santalaceae have similar acetylenic acids. Santalaceae have terpenoids.

OLACACEAE (Figure 144*a,b*).—Trees, shrubs,

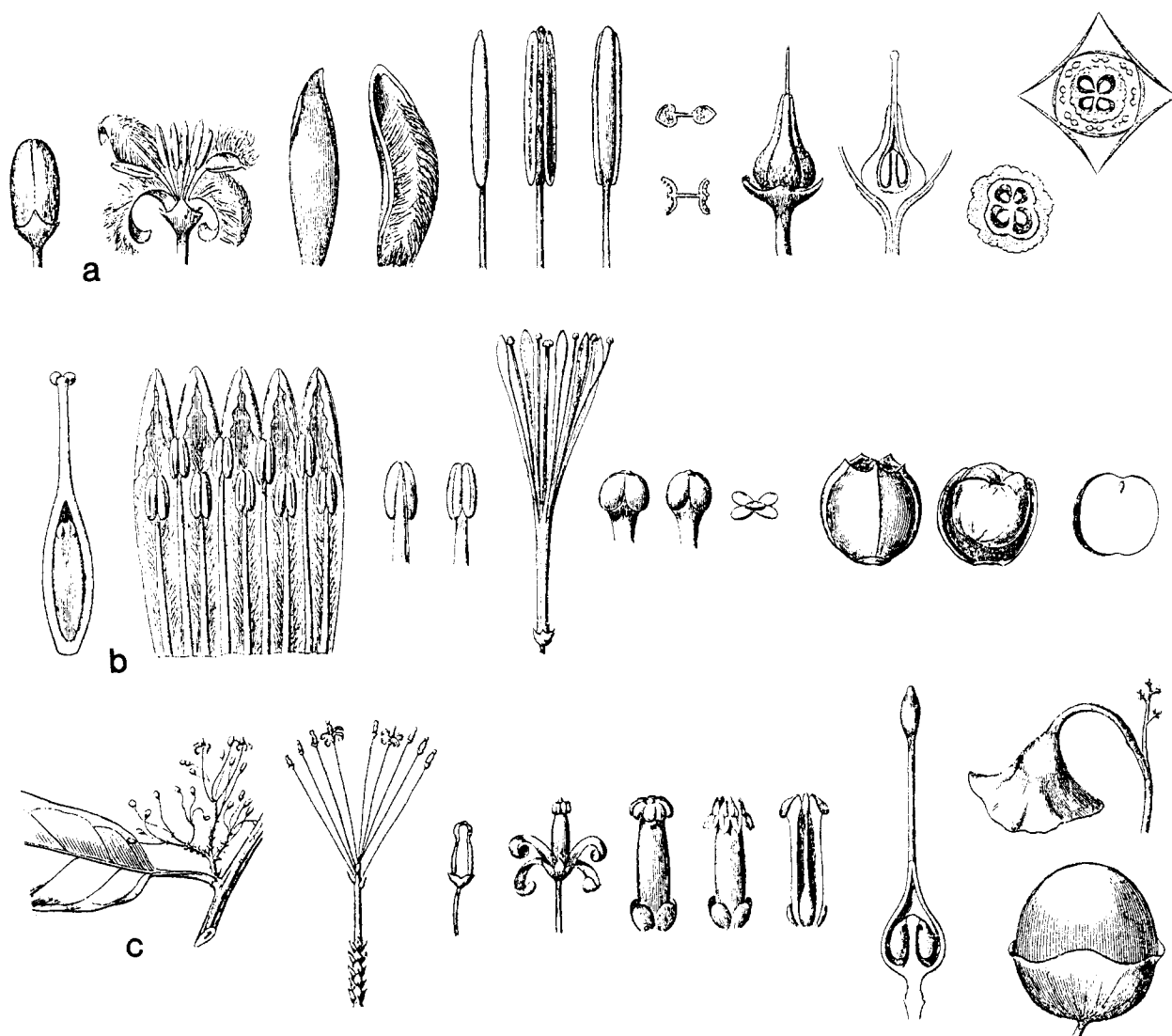


FIGURE 144.—OLACACEAE: *a*, *Ximenia coriacea* bud, flower, views of petal, views of stamen, c.s. of anther before and during dehiscence, pistil, l.s. of same, c.s. of ovary, floral diagram; *b*, *Ptychopetalum olacoides* l.s. of pistil, corolla laid open, views of anther, *Chaunochiton loranthoides* flower, views of anther, c.s. of anther, fruit, seed and arcuate placenta to left, l.s. of seed showing the minute embryo (after Martius, 1840–1906). APTANDRACEAE: *c*, *Aptandra liriosmoides* axillary inflorescence, part of inflorescence, bud, flower, staminal tube and disk before and after dehiscence of the anthers, l.s. of staminal tube to show the pistil, l.s. of ovary, *A. tubicina* accrescent calyx enclosing the immature fruit, mature fruit and calyx (below) (after Martius, 1840–1906).

and climbers, very rarely subherbaceous, in part hemiparasitic; xylem vessel perforation plates exclusively scalariform, simple, or both, usually with few bars (6–10) but more than 20 in *Heisteria*; leaves alternate, simple, entire, exstipulate;

inflorescences axillary, small, cymose, or a thyse; flowers usually bisexual, the plants sometimes polygamodioecious; sepals 3–6, connate, reduced, sometimes accrescent; petals 3–6, free or connate, mostly valvate; stamens 3–20, in 1–2

series, sometimes only opposite the petals, the filaments hypogynous or inserted on the corolla, sometimes staminodes present; anthers as long as wide or oblong, dehiscent longitudinally or by short slits, rarely by valves; pollen 3-colpate, 3-colporoidate, 3-4(5)-porate, 6(8)-forate, 3-4-diploforate; disk often annular; pistil 1, the carpels 2-5, style 1, stigma 2-5-lobed, apical; ovary superior, rarely semi-inferior, 1-5-locular at the base, usually unilocular above, the ovules 0-1-2-tegmic, tenuinucellar or pseudocrassinucellar, anatropous, mostly 1 per locule, axile or 1-5 from the apex of a free-central placenta in the unilocular ovaries; fruit a drupe or nut, the seed 1; embryo minute to medium-sized, straight, 0.3 the length of the endosperm, barely differentiated; endosperm copious, oily.

Composition: 25 genera, 240 species.

Distribution: Pantropical, especially Africa and Asia, secondarily America; warm temperate North America to warm temperate South America; Africa except the northern part; India, Japan, China, Indochina, the East Indies, north-eastern Australia, western Pacific islands.

APTANDRACEAE (Figure 144c).—Trees; xylem vessel perforation plates simple; leaves alternate, simple, entire, exstipulate; inflorescences axillary racemes or panicles, ultimate divisions umbelliform; flowers bisexual or the plants dioecious; sepals 4-8, connate, at first small, later accrescent; petals 4-8, free, valvate; stamens 5-4, connate in a column surrounding the pistil, the anthers sessile; pollen 4(5)-porate; disk annular or lobed, between the petals and stamens; pistil 1, the carpels 2, style 1, elongated or the stigmas sessile; ovary superior 2-1-locular, the ovules 2(?), pendulous from the apex of the free central placenta, ategmic; fruit a drupe, the seed 1; embryo minute, 0.2 the length of the endosperm, barely differentiated; endosperm copious, oily.

Composition: 1 genus, 4 species.

Distribution: Tropical America and west Africa; Malaya, Indochina.

OCTOKNEMACEAE (Figure 145a,b).—Trees and shrubs; xylem vessel perforation plates scalariform, usually with fewer than 20 bars, or

simple; leaves alternate, simple, entire, exstipulate; inflorescences axillary racemes; plants dioecious; sepals 5, connate, small; petals 0 or 5; stamens 5, the filaments free; anthers about as long as wide, basifixed; pollen 3-colporoidate; disk lobed or 0; pistil 1, the carpels 3-5, style 1, short, 3-5-lobed apically, the lobes bifid; ovary inferior, unilocular or nearly 3(4)-locular, the ovules 3 (4), apical, undifferentiated, the embryo sac resembles that of Olacaceae; fruit a drupe, the seed 1, longitudinally 8(6-10)-ribbed; embryo small, the radicle much longer than the cotyledons; endosperm copious, slightly ruminate.

Composition: 1 genus, 6 species.

Distribution: Tropical Africa.

OPILIACEAE (Figure 145c).—Trees, shrubs, and lianas, all or most root-parasites; xylem vessel perforation plates simple; leaves alternate, simple, entire, exstipulate; inflorescences axillary racemes, spikes, umbels or panicles; flowers bisexual or the plants dioecious; calyx minute, the lobes obsolete; petals 4-5 (0), free or connate; stamens 4-5, opposite the petals, rarely alternipetalous, the filaments short or filiform, free or epipetalous; anthers basifixed; pollen 3-colporate or 3-colporoidate; disk glands alternating with the stamens sometimes connate; pistil 1, the carpel 1, style 1, short, the stigma apical, punctiform; ovary superior or semi-inferior, unilocular, the ovule solitary, basal, 0-1-tegmic, tenuinucellar, anatropous or orthotropous; fruit a drupe; embryo small, linear, straight, 0.5 the length of the endosperm; cotyledons not broadened, 0.5 the length of the embryo; endosperm copious.

Composition: 8 genera, 60 species.

Distribution: Pantropical and -subtropical, especially Asia.

MEDUSANDRACEAE (Figure 146a,b).—Trees with secretory canals throughout, buds perulate; xylem vessel perforation plates scalariform, commonly with 20 but as many as 50 or more bars; leaves simple, alternate, crenulate, stipulate; inflorescences axillary slender pendulous racemes; flowers bisexual, actinomorphic; sepals 5, free or very shortly connate, open in bud, accrescent;

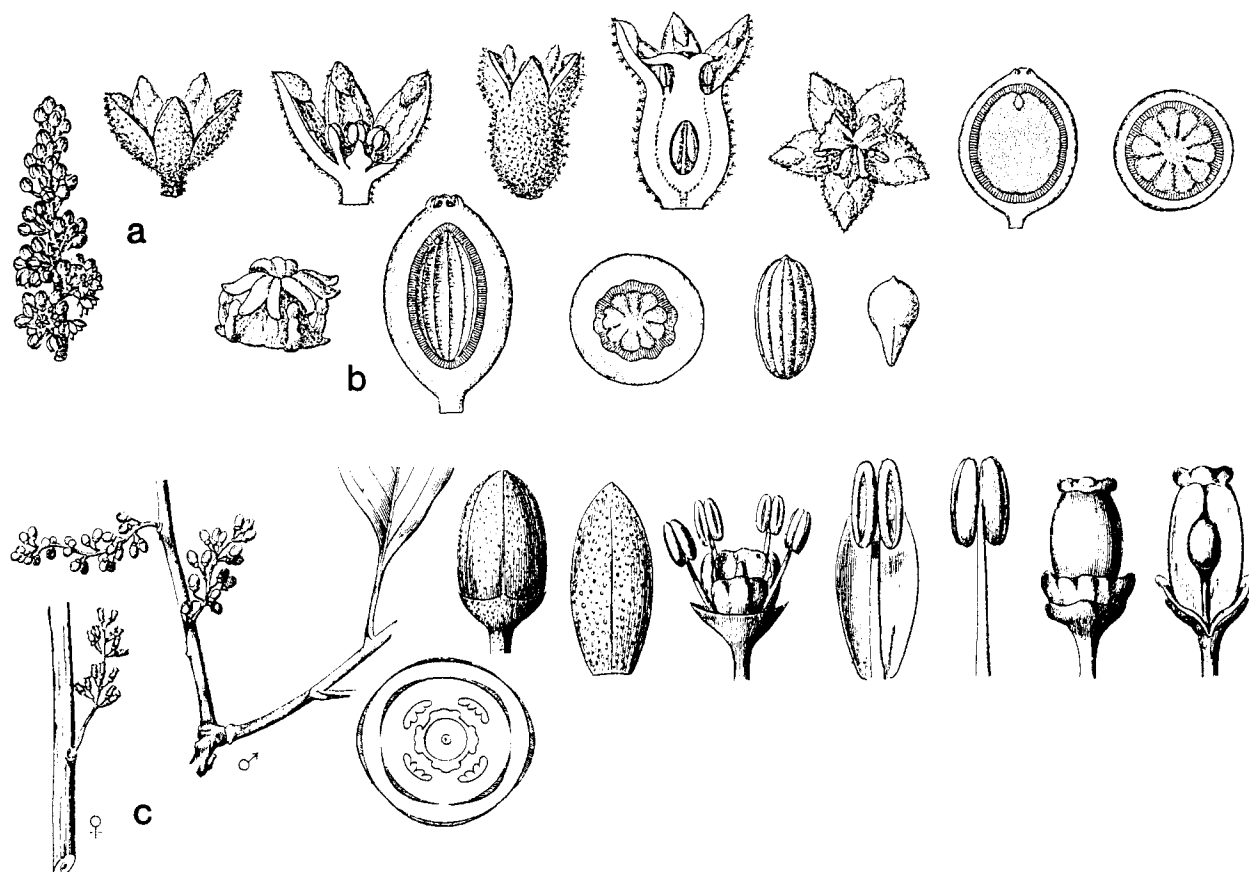


FIGURE 145.—OCTOKNEMACEAE: *a*, *Octoknema klaineana* inflorescence, ♂ flower, l.s. of same with pistillode, ♀ flower, l.s. of same, ♀ flower from above, l.s. of fruit showing the minute embryo, c.s. of fruit; *b*, *O. affinis* lateral view of stigmas, style and staminodes, *O. winkleri* l.s. and c.s. of fruit, seed, *O. affinis* embryo (enlarged) (after Pilger and Krause). OPILIACEAE: *c*, *Agonandra brasiliensis* ♀ inflorescence, part of ♂ inflorescence, floral diagram, bud, petal (dorsal view), androecium and disk, views of stamen and ventral view of petal, pistil and disk, l.s. of pistil (after Martius, 1840–1906).

petals 5, free, imbricate; stamens 5, opposit-petalous, the filaments short, not connate but often very shortly adnate to the base of the petals, staminodes 5, much elongated at anthesis, becoming several times longer than the stamens; anthers 4-locular, about as long as wide, dorsifixed, dehiscing by dorsal and ventral valves; pollen 3-colporoidate; disk absent; pistil 1, the carpels 3 (4), styles 3 (4), short, conical, free, distant, the stigmas apical, minute; ovary superior, unilocular, the placenta free central, ovules 6 (–8) apical-axile; fruit a 3(4)-valved coriaceous capsule, the seed solitary, large; embryo small,

straight, 0.3 the length of the endosperm, the cotyledons not broadened, 0.2 the length of the embryo; endosperm copious, slightly ruminant.

Composition: 1 genus, 1 species.

Distribution: Rain forest; tropical west Africa.

CARDIOPTERIDACEAE (Figure 146*c, d*).—Climbing twining herbs with articulated laticiferous tubes; xylem vessel perforation plates simple; leaves simple, alternate, entire or lobed, exstipulate; inflorescences secund axillary loose panicle of cymes, ebracteate; flowers minute, actinomorphic, ebracteate, bisexual or the plants andromonoecious; sepals 5 (4), shortly connate,

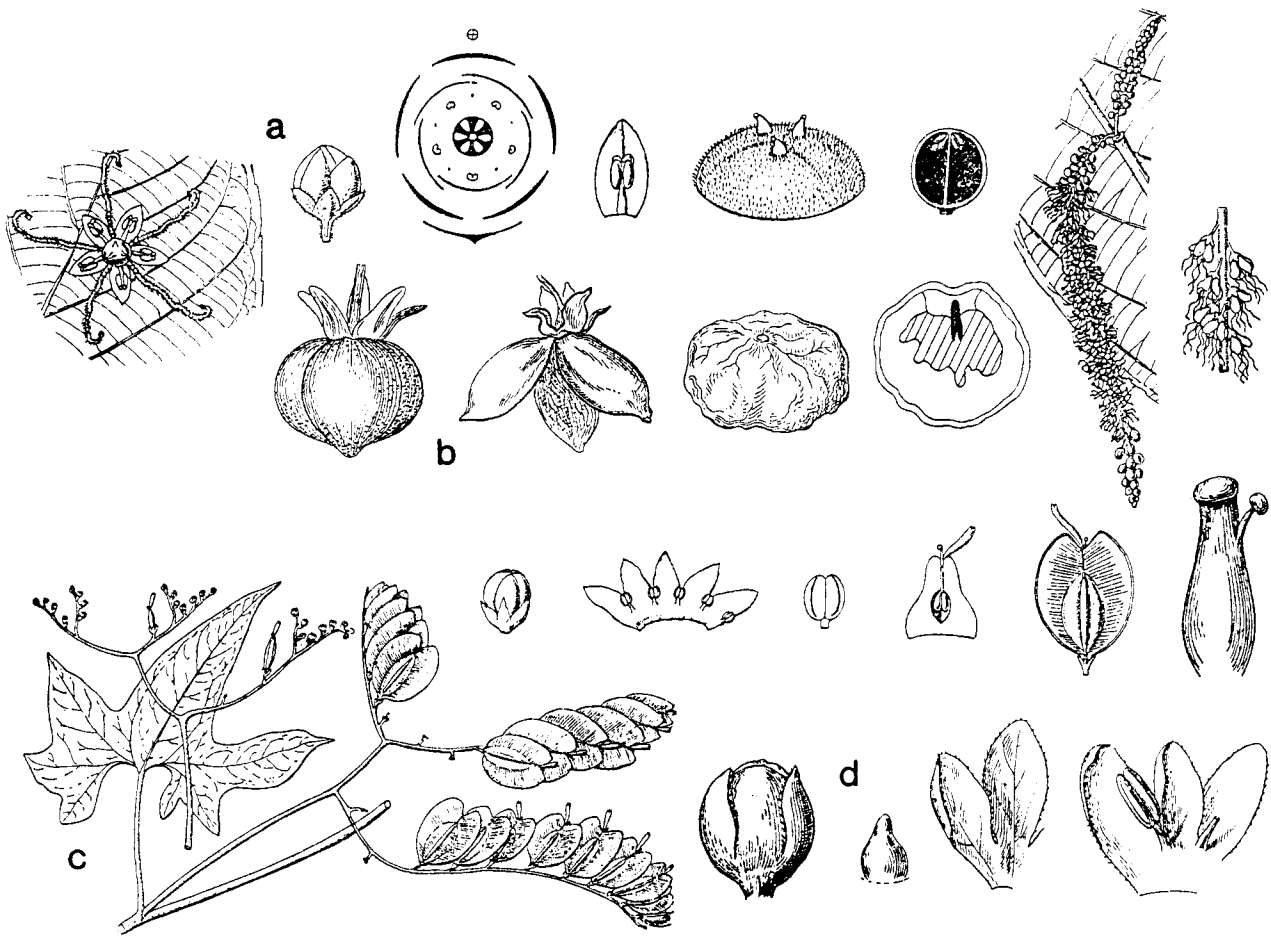


FIGURE 146.—MEDUSANDRACEAE: *a*, *Medusandra richardsiana* flower, bud, floral diagram, stamen and petal, pistil, l.s. of ovary, inflorescence, part of same enlarged; *b*, fruit, dehiscent fruit, seed, section of same showing the small embryo (black), cavity (hatched) and endosperm (after Hutchinson and Dalziel). CARDIOPTERIDACEAE: *c*, *Peripterygium quinquelobum* inflorescence superimposed on leaf, axillary infructescence, bud, corolla laid open, anther, l.s. of ovary (note the unequal styles), fruit, *P. platycarpum* pistil; *d*, bud of ♂ flower, pistillode, 2 sepals, 3 petals and a stamen (after Hutchinson, 1973; Lecomte).

imbricate; petals 5 (4), shortly connate, imbricate; stamens 5 (4) adnate to the corolla, alternipetalous, the filaments short, anthers dorsifixed, about as long as wide to oblong, longitudinally dehiscent; pollen 3-colpor(oid)ate; disk 0; pistil 1, the carpels 2, styles 2 or 1 and apically bifid, one accrescent, the other short, the stigmas apical, capitate; ovary superior, unilocular, the ovules 2, naked(?), one sometimes aborting, apical; fruit a flat samara, the seed 1, linear; embryo very minute, the endosperm copious, fleshy.

Composition: 1 genus, 3 species.

Distribution: Assam, southeastern Asia, Malaysia, Queensland.

SANTALACEAE (Figure 147*a,b*).—Trees, shrubs, and herbs, sometimes parasitic on roots or stems (*Phacellaria* on Loranthaceae); xylem vessel perforation plates simple; leaves alternate or opposite, simple, entire, sometimes reduced to scales, exstipulate; inflorescences axillary and terminal racemes, spikes, heads, often cymose, sometimes the flower solitary; flowers small, bi-

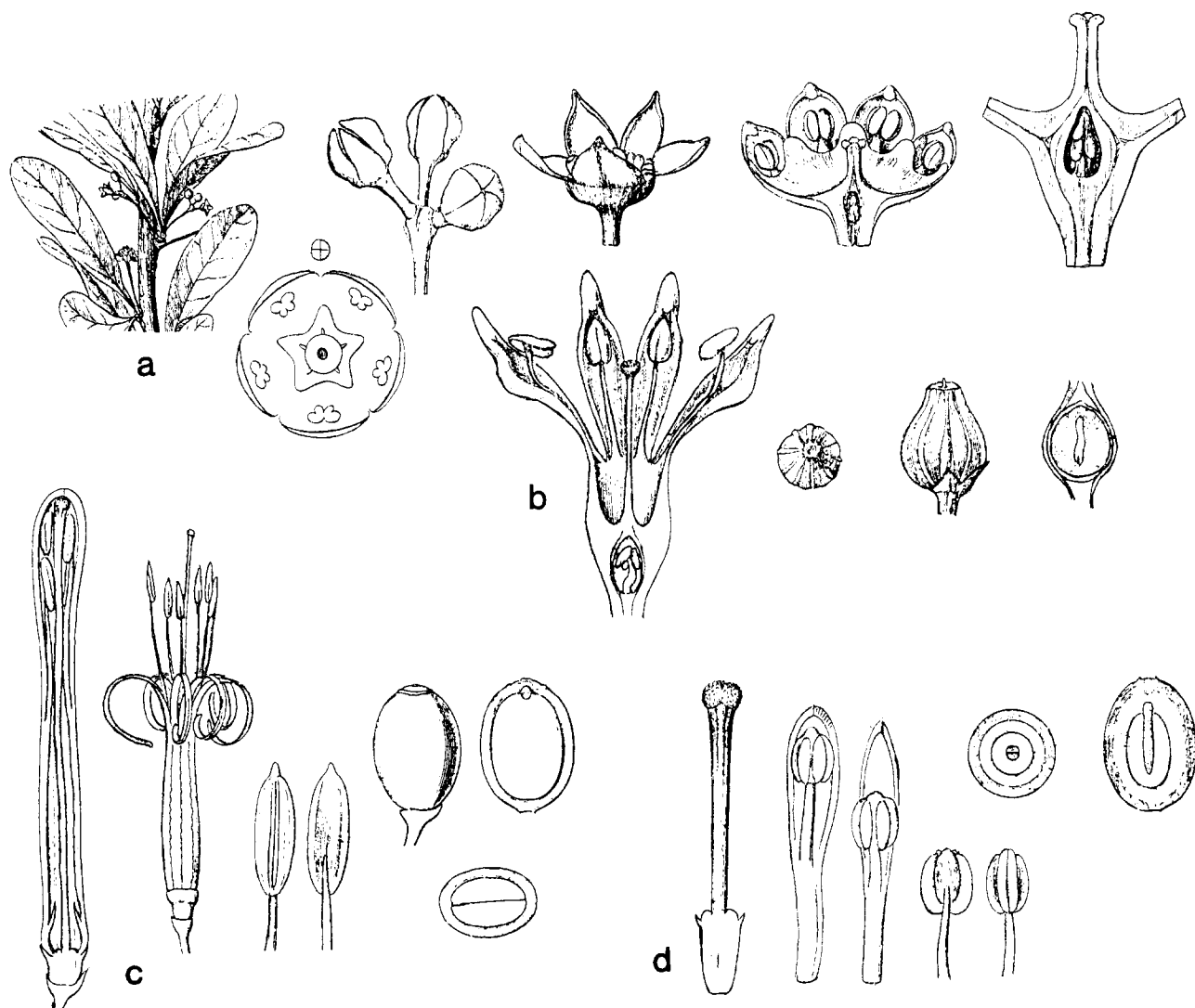


FIGURE 147.—SANTALACEAE: *a*, *Acanthosyris spinescens* part of flowering branch, floral diagram, inflorescence in bud, flower, l.s. of same laid open (also showing disk), l.s. of ovary; *b*, *Thesium aphyllum* l.s. of flower, apical and lateral views of fruit, l.s. of same showing seed with embryo and endosperm (after Martius, 1840–1906). LORANTHACEAE: *c*, *Psittacanthus glaucoma* l.s. of bud, *P. biternatus* flower, views of anther, fruit, l.s. and c.s. of same; *d*, *Struthanthus vulgaris* pistil, petal and stamen of exterior series, same of interior series, views of stamen of interior series, c.s. and l.s. of fruit (embryo linear, surrounded by endosperm) (after Martius, 1840–1906).

sexual or the plants monoecious or dioecious; sepals 3–6, free or basally connate, valvate or slightly imbricate, sepaloid or petaloid; petals 0; stamens 3–6, inserted on the calyx opposite the lobes; anthers about as long as wide, basifixed or dorsifixed; pollen 3-brevicolpate, colpoidate,

3-colporate, 3-porate; disk perigynous or epigynous; pistil 1, the carpels (2) 3–5, style 1, the stigma 1 and capitate or (2) 3–5-lobed; ovary unilocular, inferior, semi-inferior or rarely superior (Anthoboleae), the ovules 1–3 (4, 5), not developed in Anthoboleae, basal, 0–1-tegmic,

tenuinucellar, orthotropous, anatropous or semi-anatropous; fruit a nut or drupe; seed 1, without a testa; embryo linear, terete, straight or minute and undifferentiated, 0.1–0.95 the length of the endosperm; cotyledons thin, 0.3–0.7 the length of the embryo; endosperm copious, fleshy.

Composition: 30 genera, 400 species.

Distribution: Often dry habitats; cosmopolitan except the arctic region, most common in tropics and subtropics.

LORANTHACEAE (Figure 147*c,d*).—Shrubs, more rarely herbs, hemiparasites on the branches of trees or rarely terrestrial trees or shrubs parasitic on roots; xylem vessel perforation plates simple; secretory canals and intraxylary or extraxylary phloem sometimes present; leaves mostly opposite or whorled, rarely alternate, simple, entire, sometimes reduced to scales, exstipulate; inflorescences cymose, sometimes spikes or racemes, the flowers solitary or 2–3 together in axils of bracts or extra-axillary, rarely terminal; flowers bisexual or the plant dioecious; sepals 3–4, free above the ovary or connate and 4–6-toothed or truncate (0 in *Antidaphne*); petals 4–6 or 0, free or connate; stamens 3–6, epigynous or inserted on the perianth opposite the lobes or at their base; anthers dorsifixed, sometimes unilocular or transversely locellate, dehiscing longitudinally or by terminal pores or transverse slits; pollen 3(2–4)-colpate, less frequently colp(oid)ate; disk present or absent; pistil 1, the carpels 3(?), style 1 or the stigma sessile, apical; ovary inferior, unilocular, the ovules not differentiated, the placenta basal; fruit a berry, drupe or samaroid; seed 1, without a testa; embryo linear, small, straight, 0.3–1.25 times the length of the endosperm; cotyledons sometimes 3–6 or 0, 0.1–0.5 the length of the embryo; endosperm copious, succulent or sometimes 0.

Composition: 35 genera, 1300 species.

Distribution: Pantropical, especially Southern Hemisphere, extending into the temperate zones.

MISODENDRACEAE (Figure 148*a–c*).—Subshrubs hemiparasites on the branches of *Nothofagus* trees; xylem vessel perforation plates sim-

ple; leaves alternate, simple, entire or crenate, sometimes scale-like, exstipulate; plants dioecious; inflorescences axillary and terminal small spikes, racemes, head or the flowers solitary; ♂ flower: perianth 0; stamens 2–3 (1–4), the filaments elongated, inserted around a disk; anthers basifixed, unilocular, dehiscing by 2 valves or a tangential slit; pollen 4–12-forate; ♀ flower: calyx adnate to ovary?; petals 0; disk epigynous; pistil 1, the carpels 3, style 1, short, the stigmas 3, decurrent ventrally; ovary inferior, incompletely 3-locular, the ovules 3, basal; fruit a nutlet or achene distributed by 3 enlarged, feathery setae; seed 1, without a testa; embryo straight, minute, 0.1–0.3 the length of the endosperm; cotyledons minute, hardly differentiated, shorter than the radicle; endosperm copious, fleshy.

Composition: 1 genus, 10 species.

Distribution: *Nothofagus* forests of southern third of the Andes.

GRUBBIACEAE (Figure 149*a,b*).—Small shrubs, not parasitic; xylem vessel perforation plates scalariform, with 20–40 or more bars; leaves opposite, simple, linear, entire, exstipulate; inflorescences axillary 3-flowered dichasia or strobiloid compound dichasia; flowers bisexual, minute; sepals 4, valvate; petals 0; stamens 8, in 2 series, the filaments free; anthers medifixed or basifixed, small, dehiscing by valves; pollen 3-colporate, 3-colporoidate; disk epigynous, annular; pistil 1, the carpels 2, style 1, short, the stigmas 2, apical; ovary inferior, initially bilocular, becoming unilocular, the ovules 2, unitegmic, tenuinucellar, anatropous, the placentas axile, becoming free-central or basal; fruit a drupe or nutlet, the seed 1; embryo linear, subterete, 0.7–0.8 the length of the endosperm; cotyledons as wide as the radicle, 0.3–0.4 the length of the embryo; endosperm copious, fleshy and oily.

Composition: 1 genus, 5 species.

Distribution: Cape Province, South Africa.

THYMELAEALES

Trees and shrubs, rarely herbs or lianas, usually with tough fibrous bast; xylem vessel perfo-

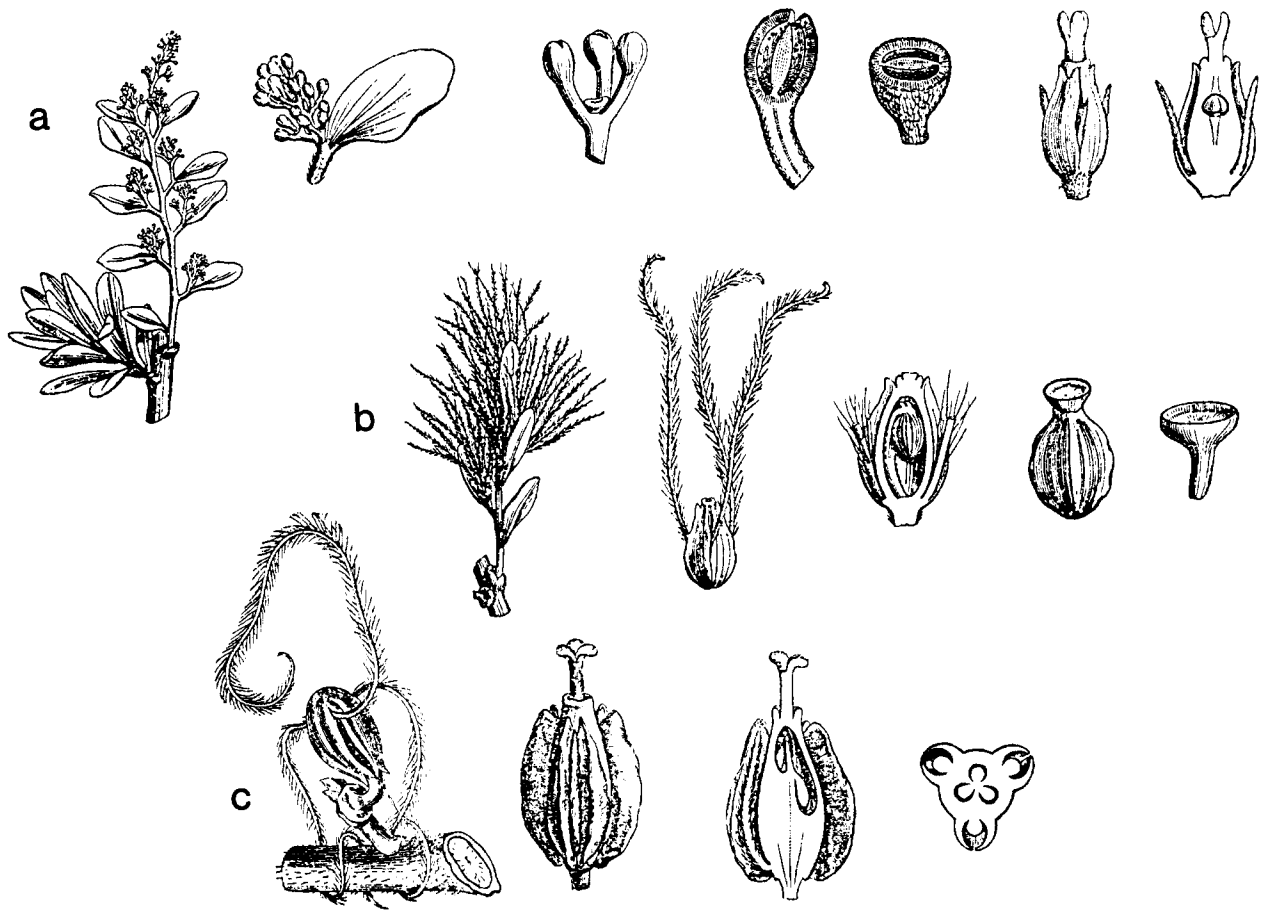


FIGURE 148.—MISODENDRACEAE: *a*, *Misodendron punctulatum* ♂ plant, leaf with ♂ inflorescence, ♂ flower, l.s. and c.s. of anther, ♀ flower, l.s. of same; *b*, ♀ plant in fruit, fruit, l.s. of same, seed with embryo at apex, embryo; *c*, *M. brachystachyum* seed germinating within the fruit and attaching to a branch, ♀ flower, l.s. of same, c.s. of ovary (after Le Maout and Decaisne, 1873; Baillon, 1866–1895; Hooker and Hooker, 1837–1982).

ration plates usually simple, rarely scalariform; intraxylary phloem usually present, sometimes interxylary phloem, occasionally mucilaginous secretory canals and spaces; leaves alternate or opposite, simple, entire, mostly exstipulate; flowers usually bisexual; sepals 4–5 (3–6), connate into a tube, rarely nearly free, often petaloid; petals 0 or 4–12, mostly scale-like, free or connate, inserted on the calyx tube; stamens 4–10 (1 to ~80) in 1 or 2 series, inserted on the calyx, the filaments mostly not connate; anthers basifixed, dorsifixed or adnate, rarely apiculate; pollen usually oligo-polyporate, sometimes 3-colpor-

ate; glandular disk hypogynous or adnate to the calyx, sometimes absent; pistil 1, the carpels 2 (3–12), often pseudomonomerous, often heterostylous, the styles 1 (4), often excentric, stigma(s) apical; ovary superior, 1(2–12)-locular, the ovules 1 (2) per locule, axile, sometimes subapical; embryo sac sometimes with increased number of antipodals; fruit usually an achene, nut, berry, or drupe, sometimes enclosed by a fleshy calyx tube, rarely a loculicidal capsule, the seed(s) often arillate or carunculate; embryo usually large, straight; endosperm mostly scanty or absent, rarely copious.

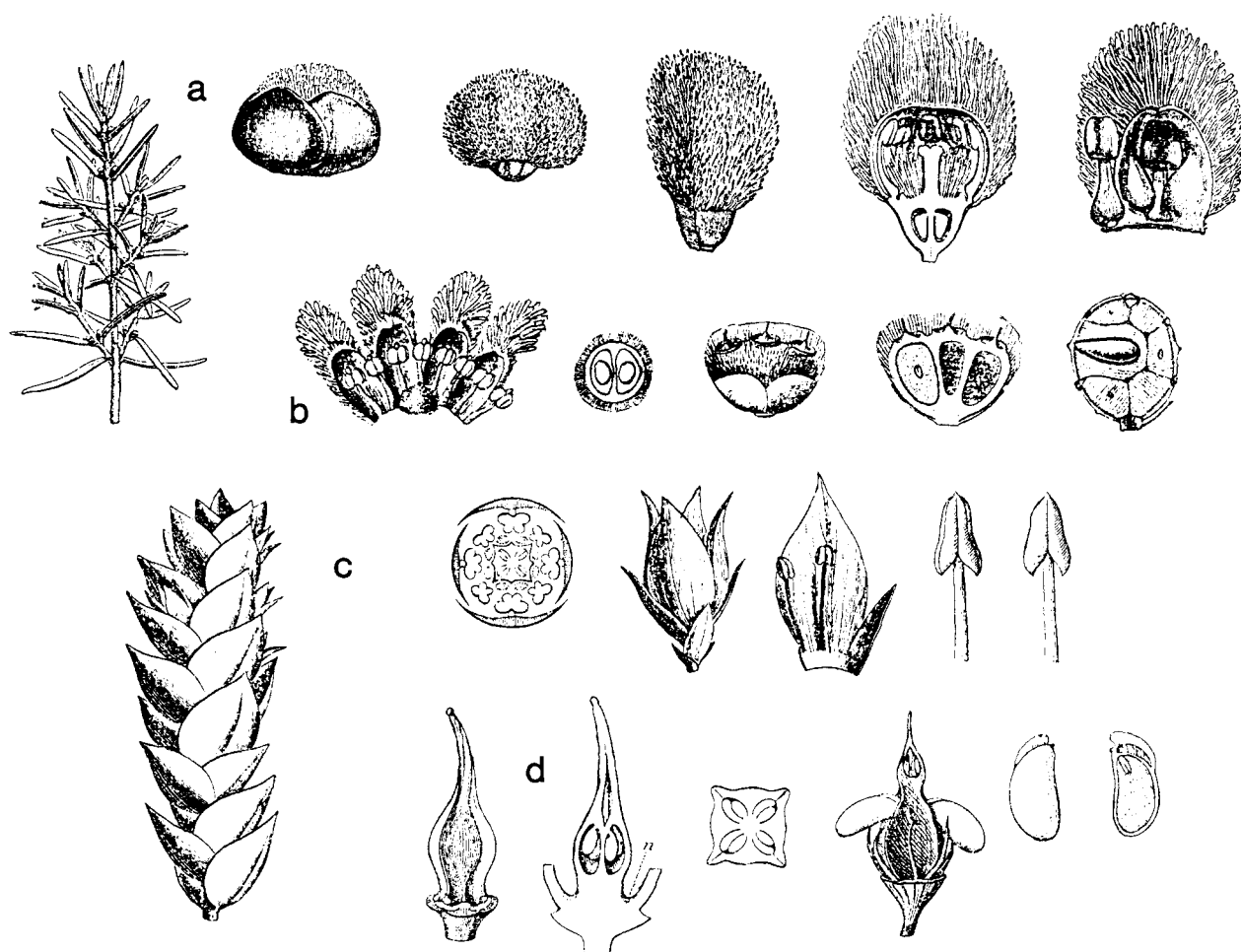


FIGURE 149.—GRUBBIACEAE: *a*, *Grubbia rosmarinifolia* flowering shoot, glomerule with its bracts and without them, single flower, l.s. of same, petal and stamens; *b*, flower laid open, c.s. of ovary, fruit from 3 flowers, l.s. of same showing 1 fertile fruit and minute embryo in abundant endosperm, *G. stricta* l.s. of fruit showing the entire seed (after Baillon, 1866–1895; Marloth, 1925). GEISSOLOMATACEAE: *c*, *Geissoloma marginatum* flowering twig, floral diagram (nectar foveoles internal to the stamens), flower, part of perianth showing insertion of stamens, views of anther; *d*, pistil, l.s. of same, c.s. of ovary, dehiscent fruit (the seeds of 2 locules exserted), seed with aril, l.s. of same showing the minute embryo (after Marloth, 1925; Gilg).

Distribution: Centered in Africa and Australia, extending to temperate and tropical Eurasia and America.

GEISSOLOMATACEAE (Figure 149*c,d*).—A low shrub; xylem vessel perforation plates scalariform with 12–33 bars; intraxylary phloem absent; leaves simple, opposite, decussate, entire, coriaceous, the stipules minute, 1 mm., or absent(?); flowers solitary, bisexual, axillary, acti-

nomorphic, closely subtended by 6 decussate bracts; sepals 4, very shortly connate, shortly acuminate, petaloid, imbricate in bud; petals 0; stamens 8, in 2 whorls, inserted on the base of the calyx, the filaments elongated, not connate; anthers dorsifixed, ellipsoid, small, about as long as wide, the connective slightly produced apically, the sacs basally separate, dehiscing longitudinally; pollen 3-colporate; 8 foveolate glands

present between the ovary and stamens; pistil 1, the carpels 4, styles 4, free basally, connate apically, the stigma(s) apical, not enlarged; ovary superior, 4-locular, the carpels loosely connate, the ovules 2 per locule, apical-axile, bitegmic, anatropous, the embryo sac 8 nucleate (*Polygonum* type); fruit a 4-winged loculicidal capsule, the seeds often 1 per locule, carunculate; embryo straight, as long as the endosperm according to some, with foliaceous or linear cotyledons and short radicle, but the illustration in Marloth shows a small embryo, 0.2 the length of the endosperm and cotyledons 0.5 the length of the embryo; endosperm copious, fleshy.

Composition: 1 genus, 1 species.

Distribution: South Africa, in dry habitats.

GYNSTYLACEAE (Figure 150*a,b*).—Trees, sometimes large, rarely shrubs; xylem vessel perforation plates simple, phloem fibers abundant, intraxylary phloem absent, mucilage secretory cells or spaces usually present in the leaves and stem; leaves alternate or rarely opposite or subopposite, simple, entire, coriaceous, the lateral veins numerous, relatively inconspicuous, the midrib prominent beneath, mostly glandular-punctate, exstipulate; inflorescences a terminal thyrse or rarely subumbel; flowers bisexual, actinomorphic; sepals 5, shortly connate, the lobes imbricate or rarely valvate in bud; petals minute (disk of some authors) 7–40, deltoid to linear-subulate or rarely an entire low annulus; stamens usually numerous, 8–80, the filaments free or rarely connate in groups (*Lethedon* spp.), inserted on the base of the calyx, the filaments short, filiform; anthers oblong, basifixed, sometimes hippocrepiform, dehiscent longitudinally; pollen oligoforesate, with small spinulose excrescences; disk 0; pistil 1, the carpels 3, 5 (2–12), style 1, elongated, filiform, bent, much longer than the stamens, sometimes parastyles present, the stigma small, capitate, clavate or rarely obscurely lobed; ovary 3, 5 (2–12)-locular, the ovules 1 per locule, axile-subapical, bitegmic, crassinucellar, anatropous; fruit usually a woody loculicidal capsule, or rarely soft (indehiscent?), the seeds large, arillate; cotyledons thick, radicle short; endosperm 0.

Composition: 1 genus, 25 species.

Distribution: Southeastern Asia, the East Indies to Fiji.

THYMELAEACEAE (Figure 150*c,d*).—Usually shrubs, sometimes trees, rarely herbs or lianas, with tough fibrous bast, many poisonous with acrid, rarely caustic sap; xylem vessel perforation plates simple, intraxylary phloem present except in *Laetia* and *Drapetes*, interxylary phloem occurs in some genera, mucilaginous secretory canals and spaces sometimes present; leaves alternate or opposite, simple, entire, exstipulate; inflorescences terminal, axillary, at nodes of fallen leaves, rarely cauliflorous, spikes, racemes, heads, umbels, fascicles or rarely cymes, or the flowers rarely solitary, sometimes involucre, the bracts rarely colored; flowers usually bisexual or sometimes the plants dioecious or polygamous, actinomorphic or rarely slightly zygomorphic, rarely dimorphic, often sweetly scented; sepals 4–5 (3–6), connate into a tube or rarely nearly free, the calyx often petaloid, the lobes imbricate in bud or rarely absent; petals 4–12, mostly scale-like, free, connate or absent, usually smaller than the calyx lobes, inserted on the calyx-tube at its mouth or slightly below; stamens 4–10 (1–2 in *Pimelea*), usually in 2 series, sometimes 1 and then opposite or alternate with the calyx lobes, inserted on the calyx-tube at its mouth or within the tube, the filaments short or long, not connate; anthers as long as to twice as long as wide, basifixed, dorsifixed or adnate, rarely the connective produced apically, dehiscent longitudinally; pollen usually oligo-polyforesate, usually with vestigial spinuloid excrescences and patterns \pm similar to the “croton-pattern;” disk hypogynous, annular, cupular, or of separate scales or sometimes adnate to the calyx-tube or 0; pistil 1, sometimes stipitate, pseudomonomerous or the carpels 2, often heterostylous, the style 1, short or elongated, often excentric, the stigma capitate, discoid or ovoid, often papillose or penicillate, rarely punctiform; ovary superior, 1(2)-locular, the ovules 1 per ovary or locule, pendulous, but vascular strand basal, or axile, bitegmic, crassinucellar, anatropous or rarely semi-anatropous to nearly orthotropous, the embryo sac

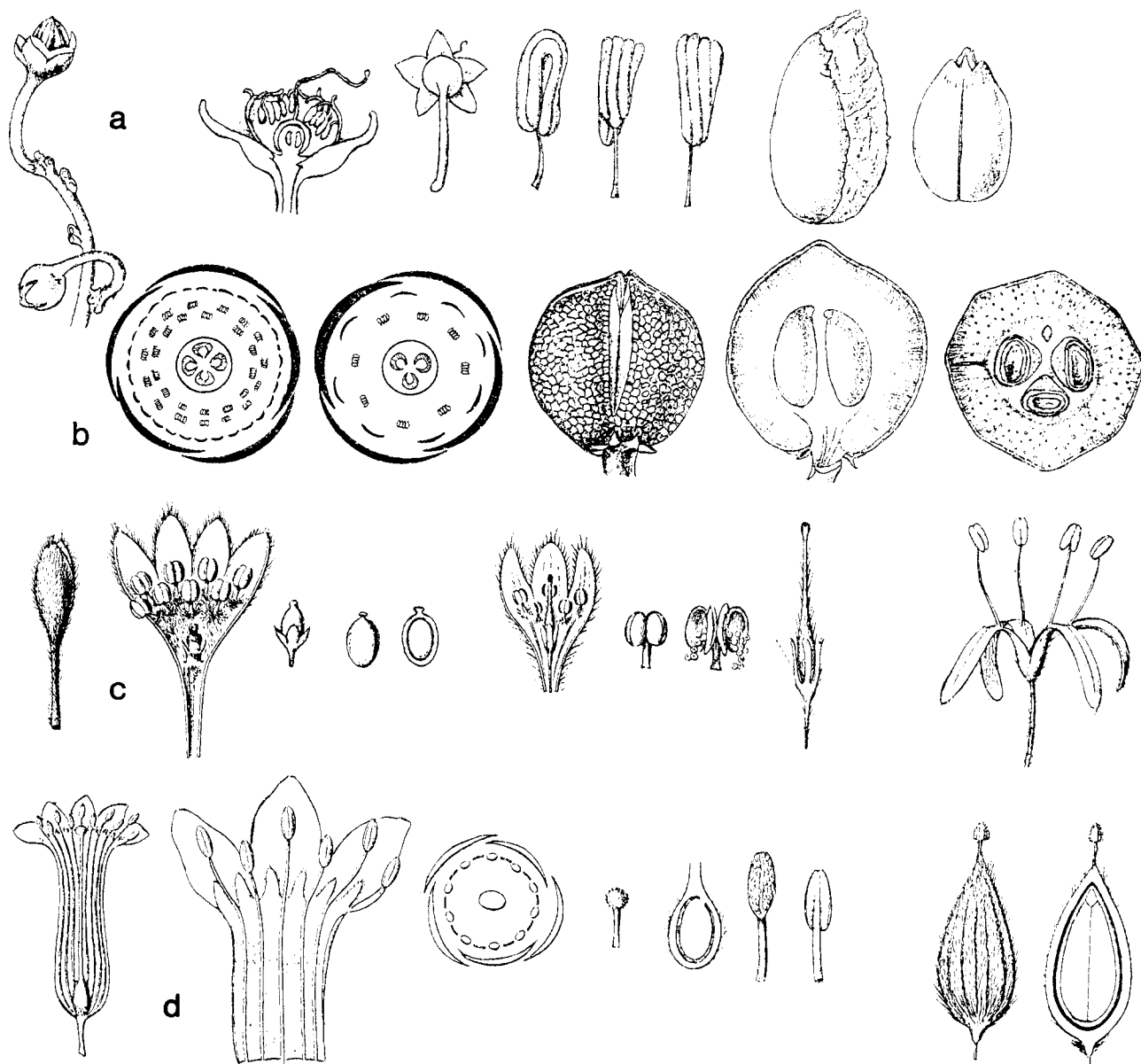


FIGURE 150.—GONYSTYLACEAE: *a*, *Gonystylus bancanus* part of inflorescence, l.s. of flower, calyx from below, views of stamen, seed, embryo; *b*, *G. borneensis* floral diagram, *G. forbesii* floral diagram, *G. bancanus* fruit, l.s. and c.s. of same (after Koorders and Valetton, Domke, Miquel). THYMELAEACEAE: *c*, *Daphnopsis brasiliensis* bud, ♂ flower with pistillode (enlarged), ♀ flower, fruit, l.s. of same, *D. martii* part of ♂ flower laid open, with pistillode, anther before and during dehiscence, pistillode with hypogynous glands, *Schoenobiblus daphnoides* ♂ flower; *d*, *Linostoma calophylloides* flower laid open, portion of perianth further enlarged showing the squamulae on the perianth, floral diagram, stigma, l.s. of ovary, views of anther, *Lasiadenia rupestris* fruit, l.s. of same showing seed and embryo (after Martius, 1840–1906).

sometimes with increased number of antipodals; fruit an achene, nut, berry or drupe, sometimes enclosed by a fleshy calyx-tube, rarely a loculicidal capsule (*Aquilaria*, *Gyrinops*), the seed(s) often arillate or carunculate; embryo straight, as long as the endosperm, the cotyledons thick, plano-convex, rarely flat (*Gnidia bakeri*), rarely narrow and semi-cylindrical (*Lachnaea*, *Pimelea*, *Rhamnoneuron*), 0.6–0.9 the length of the embryo and to 5.5 times wider than the radicle, the latter sometimes invested; endosperm mostly scanty or absent, rarely copious (*Lachnaea*, *Pimelea*).

Composition: 48 genera, ~500 species.

Distribution: Centered in Africa and Australia, extending to temperate and tropical Eurasia, the East Indies and New Zealand; disjunct areas in temperate and tropical America.

POLEMONIALES

Herbs, shrubs, lianas, and small trees; xylem vessel perforation plates simple, occasionally also scalariform with few bars; leaves alternate, less commonly opposite, usually entire and simple, sometimes toothed, lobed, or compound, exstipulate; flowers bisexual, rarely unisexual, actinomorphic, rarely zygomorphic; sepals 5 (4–12), free or connate; petals 5 (4–12), connate, sometimes with coronal scales; stamens 5 (1, 4–15) in 1 (2) series, epipetalous, rarely inserted at 2 levels, rarely unequal, rarely some staminodal; anthers dorsifixed or basifixed, sometimes acute apically, rarely connate; pollen 3(2–12)-colporate, 6–10-porate, oligo-polyforate, 3–8-colpoidorate, 3-colporoidate, sometimes 3-colp(or)ate-3-pseudo-colpate, 2-colpate, 6–9-rugate; glandular disk annular, hypogynous, or absent; pistil 1, the carpels 2–3 (4), sometimes heterostyled, the style 1 (2), sometimes 2–4-lobed, often gynobasic, the stigmas apical or linear; ovary superior, very rarely semi-inferior, 1–3 (4–10)-locular, the ovules 1–many per locule, axile or parietal, sometimes subbasal, unitegmic, rarely bitegmic; fruit nutlets, drupe, berry, or loculicidal or rarely septicidal capsule; seeds rarely winged or long-hairy; embryo straight or slightly curved,

rarely folded, usually large; endosperm copious to absent.

Distribution: Cosmopolitan, most common in western America and the Mediterranean region, most common in dry habitats.

Chemistry: Boraginaceae seed-fats have some unusual fatty-acids. It is the only family in the “Tubiflorae” with pyrrolizidine alkaloids, and in great number.

POLEMONIACEAE (Figure 151a–c).—Herbs or rarely shrubs, lianas, or a small tree (*Cantua*); xylem vessel perforation plates simple, also scalariform with 1–10 bars in some species; leaves alternate or opposite, entire, rarely toothed (*Loeselia*) or pinnately compound, exstipulate; inflorescences terminal, rarely axillary corymbs, involucrate heads or cymes, rarely the flowers solitary (*Cobaea*); flowers bisexual, actinomorphic, rarely somewhat zygomorphic; sepals 5 (4), connate; petals 5 (4), connate, contorted in bud; stamens 5, epipetalous, alternate with the corolla lobes, the filaments long or short; anthers longer than wide, dorsifixed; pollen 6–10-porate, oligo-polyforate, or 3–8-colpoidorate; disk annular, surrounding the base of the ovary; pistil 1, the carpels 3 (2, 4), the style 1, filiform, the stigmas 3 (2, 4), linear; ovary superior, 3(2, 4)-locular, the ovules 1 or more per locule, axile, unitegmic, tenuinucellar, anatropous; fruit a loculicidal or rarely septicidal (*Cobaea*) capsule, or rarely indehiscent; seeds rarely minute; embryo straight or slightly curved, 0.9 the length of the endosperm; cotyledons moderately thick, 1–2.8 times the width of the radicle, 0.3–0.6 the length of the embryo; endosperm mostly copious or moderate, fleshy or firm-fleshy, sparse or lacking in *Cobaea*, *Cantua*, and *Bonplandia*.

Composition: 16 genera, 300 species.

Distribution: Centered in temperate western North America; most of North America; Alaska to the southern tip of South America; temperate Eurasia.

FOUQUIERIACEAE (Figure 151d,e).—Shrubs and small trees; xylem vessel perforation plates simple or with occasional scalariform plates with a few bars; leaves alternate, simple, entire, the

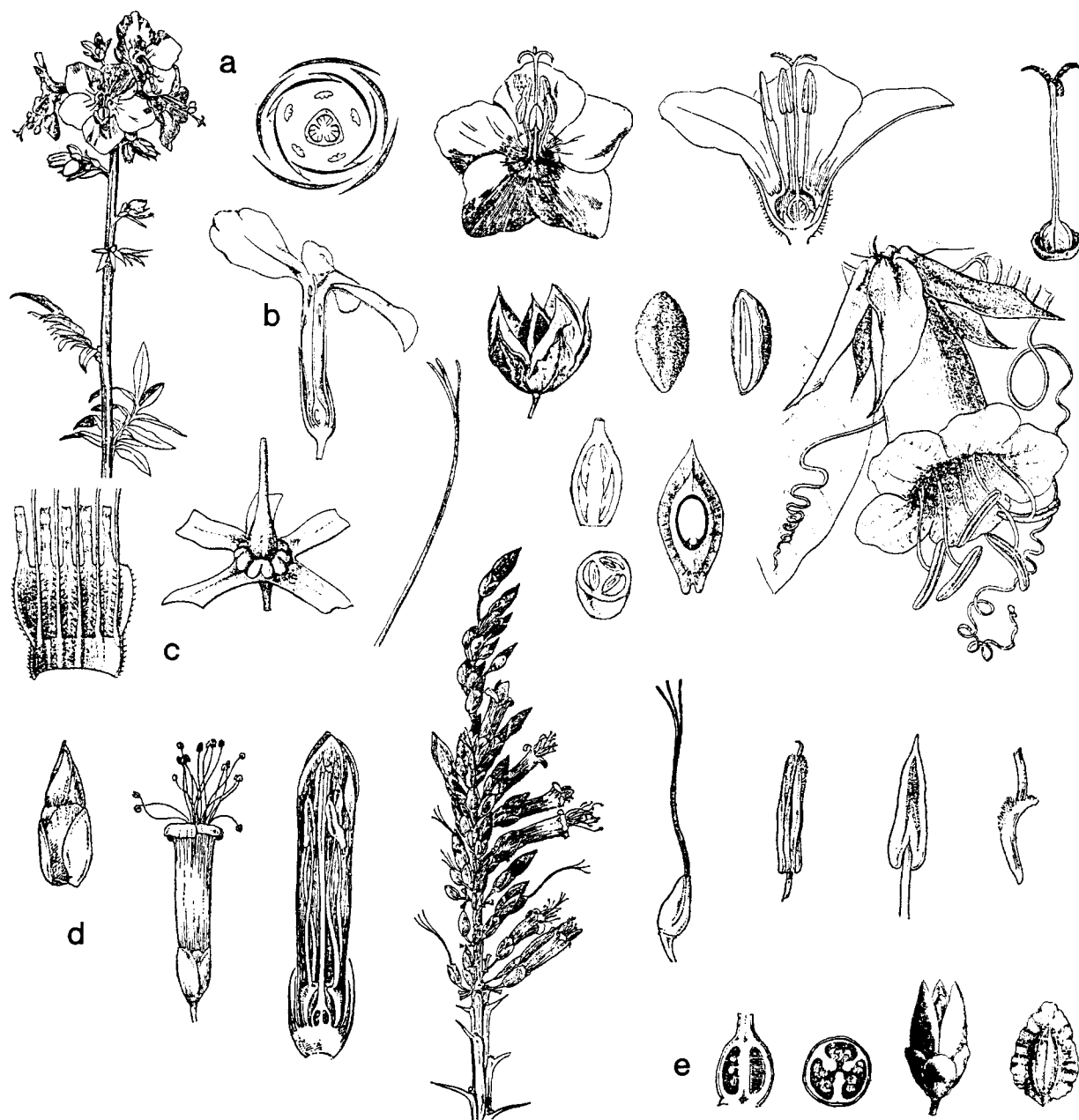


FIGURE 151.—POLEMONIACEAE: *a*, *Polemonium caeruleum* flowering shoot, floral diagram, flower, l.s. of same, pistil; *b*, *Phlox suaveolens* l.s. of flower, dehiscent fruit with calyx, seed, l.s. of same; *c*, *Cobaea penduliflora* inferior part of corolla laid open to show insertion of stamens, ovary and disk and part of calyx, stigma and part of style, l.s. and c.s. of ovary, l.s. of seed, *C. trianaei* flower (after Le Maout and Decaisne, 1873; Baillon, 1866–1895; Karsten; Hooker and Hooker, 1837–1982). FOUQUIERIACEAE: *d*, *Fouquieria splendens* bud, flower, l.s. of same, flowering twig, pistil, views of anther and base of filament; *e*, l.s. and c.s. of ovary, *F. spinosa* dehiscent fruit, seed (after Johnson, Niedenzu).

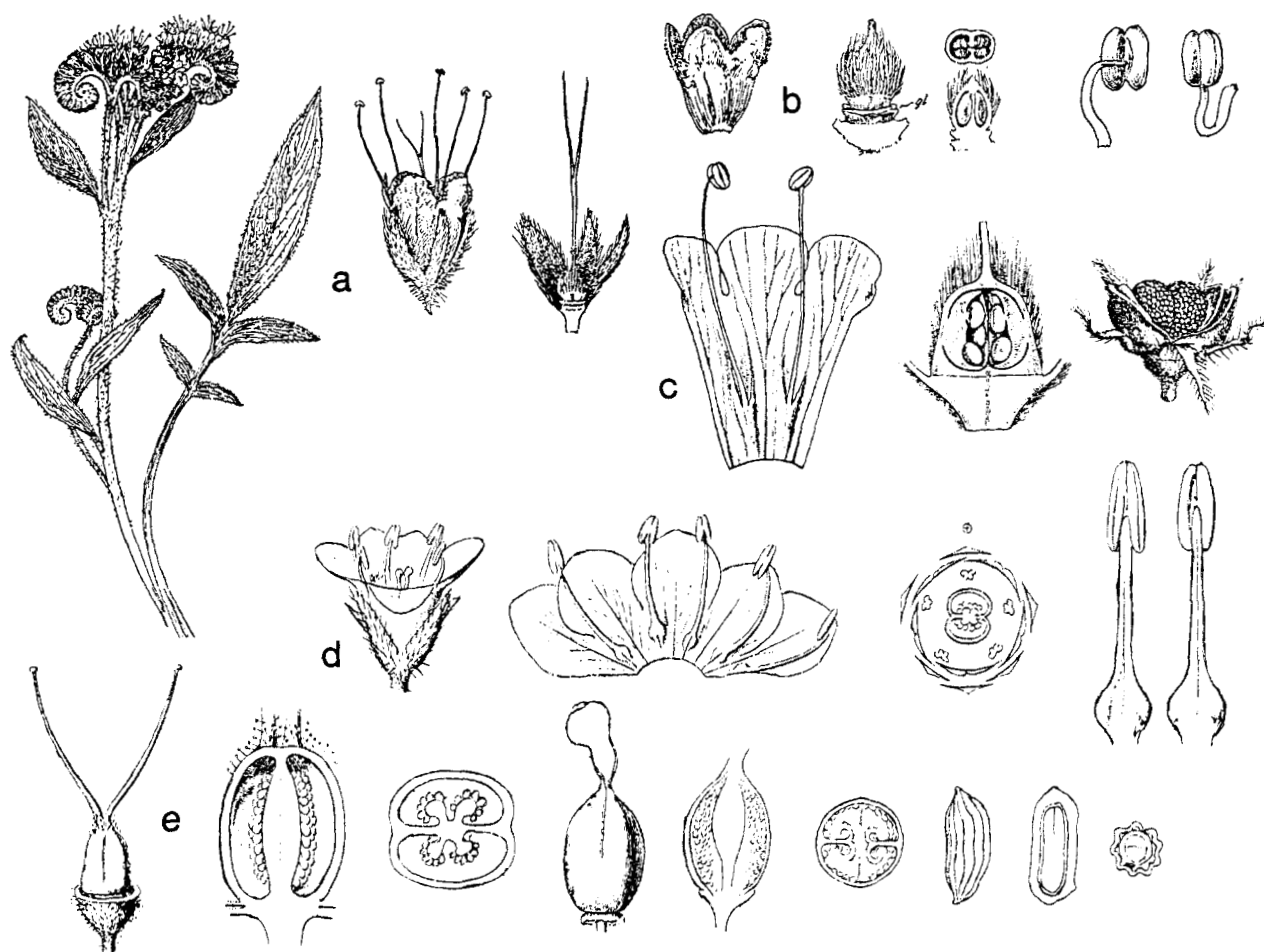


FIGURE 152.—HYDROPHYLLACEAE: *a*, *Phacelia californica* flowering shoot, flower, pistil and part of calyx; *b*, corolla, ovary and hypogynous disk, c.s. and l.s. of ovary, views of stamen; *c*, *P. pinnatifida* part of corolla laid open, *Hydrophyllum virginianum* l.s. of ovary, dehiscent fruit; *d*, *Hydrolea spinosa* flower, corolla laid open, floral diagram, views of stamen; *e*, pistil, l.s. and c.s. of ovary, fruit, l.s. and c.s. of same, seed, l.s. and c.s. of same showing embryo (after Johnson; Brand; Le Maout and Decaisne, 1873; Martius, 1840–1906).

petioles becoming spines, exstipulate; inflorescences terminal racemes or panicles; flowers bisexual, the parts hypogynous; sepals 5, unequal, free, markedly imbricate; petals connate high, the corolla tubular, the lobes 5, imbricate in bud; stamens 10–15 (–23), in 1–2 series, the filaments filiform, free or shortly connate; anthers about twice as long as wide, dorsifixed; pollen 3-colporate; base of the ovary glandular; pistil 1, the carpels 3, the style 1, filiform or short and stout, divided shortly or to the middle, stigma(s) 3,

linear or not divided; ovary unilocular, the placentas 3, parietal, septiform, each with 4–6 bitegmatic, tenuinucellar, anatropous ovules; fruit a 3-valved capsule; seeds compressed, winged all around or long-hairy; embryo straight, as long as the endosperm; cotyledons thin, 2.8 times wider than the radicle, 0.8 the length of the embryo; endosperm scanty, fleshy.

Composition: 1 genus, 11 species.

Distribution: Arid southwestern United States and Mexico.

HYDROPHYLLACEAE (Figure 152a-e).—Herbs, rarely subshrubs; xylem vessel perforation plates simple; leaves alternate, sometimes radical, rarely opposite, entire, lobed, or compound, the hairs often rough, exstipulate; inflorescences axillary and terminal, cymose, sometimes cincinni, dichasia or umbellate, or the flowers rarely solitary; flowers bisexual, actinomorphic; sepals 5 (6–8, 10–12 in *Codon*), free or basally connate; petals 5 (6–8, 10–12 in *Codon*), connate, the lobes imbricate, rarely contorted; stamens 5 (4, 6–8, 10–12 in *Codon*), often inserted on the corolla towards its base, sometimes differing in length and inserted at different levels, alternipetalous, often with a scale-like appendage at the base of the filament; anthers dorsifixed; pollen 3-colporoidate, sometimes 3-pseudocolpate-3-colpate or 6–9-rugate; disk hypogynous or absent; pistil 1, the carpels 2, (3 in *Romanzoffia*), styles 2, or 1 and bifid apically, the stigmas apical, capitate; ovary superior or semi-inferior (*Nama* spp.), unilocular, with 2 parietal placentas or 2(3)-locular with 2 (3) axile placentas, the ovules often numerous, sometimes only 2 per placenta (*Hydrophyllum*), unitegmic, tenuinucellar, \pm anatropous; fruit a capsule, loculicidal or rarely septicidal; seeds sometimes minute, sometimes carunculate; embryo straight, 0.2–1.0 as long as the endosperm; cotyledons 1–3 times as wide as the radicle, 0.2–0.4 the length of the embryo; endosperm copious or scanty, fleshy or hard.

Composition: 18 genera, 250 species.

Distribution: Centered in dry habitats of western United States; Alaska to temperate South America; northeastern Siberia; disjunct areas in tropical and southern Africa, Madagascar; India to Indochina, the western East Indies, and a small area in northern Australia.

BORAGINACEAE (Figure 153a-e).—Herbs, shrubs, and small trees, rarely lianas, often scabrid; xylem vessel perforation plates simple, rarely also a few reticulate (*Cordia*); leaves alternate or very rarely opposite, simple, usually entire, sometimes toothed, rarely lobed, exstipulate; inflorescences cymes, usually a coiled (scorpioid) cincinnus, rarely the flowers solitary;

flowers bisexual, rarely the plant gynodioecious (species of *Echium*) or dioecious (*Rochea*), actinomorphic, rarely zygomorphic; sepals 5 (4–7), free or basally connate; petals 5 (4–7), connate, the lobes contorted or imbricate in bud, many with coronal scales covering the entrance to the corolla-tube; stamens 5 (4–7), rarely 1 fertile and the others staminodal, inserted on the corolla, rarely at 2 levels, rarely unequal, alternipetalous; anthers rarely coherent, basifixed or basally dorsifixed, often acute apically, sometimes apically produced; pollen often 3 (2–12)-colporate, rarely 3-colporoidate, 3-colporate-3-pseudocolpate, 2-colpate; disk annular, hypogynous, or absent; pistil 1, the carpels 2, style 1, rarely 2 (*Pteleocarpa*) or bilobed, sometimes twice bilobed (*Cordia*), sometimes heterostyled, terminal or usually gynobasic, the stigmas 1–4, apical, various; ovary superior, 2 or 4(10)-locular, the ovules usually 4, subbasal or axile, unitegmic, tenuinucellar, or pseudo-crassinucellar (*Heliotropium*), anatropous or semi-anatropous; fruit 4 (8–10 in *Trigonotis*) nutlets, a drupe or berry, the seed rarely with an elaiosome; embryo straight or slightly curved, 0.7–1.0 the length of the endosperm; cotyledons moderately thick or flat, rarely folded (*Cordia*), or 2-partite (*Amsinckia*), 1 (*Ehretia*) or 1.8–2.7 times wider than the radicle, 0.4–0.9 the length of the embryo, the radicle sometimes partly invested; endosperm mostly 0, sometimes scanty or moderate, fleshy.

Composition: 100 genera, 2000 species.

Distribution: Cosmopolitan; Boraginoideae centered in western North America and the Mediterranean region; Ehretioideae and Cordioideae are tropical and subtropical.

SCROPHULARIALES

Herbs, shrubs, lianas, and trees, sometimes root parasites; xylem vessel perforation plates simple; intraxylary or interxylary phloem sometimes present; leaves opposite or alternate, simple, less commonly compound, entire or toothed, lobed, or dissected, sometimes reduced to scales, rarely with insectivorous bladders, rarely with a

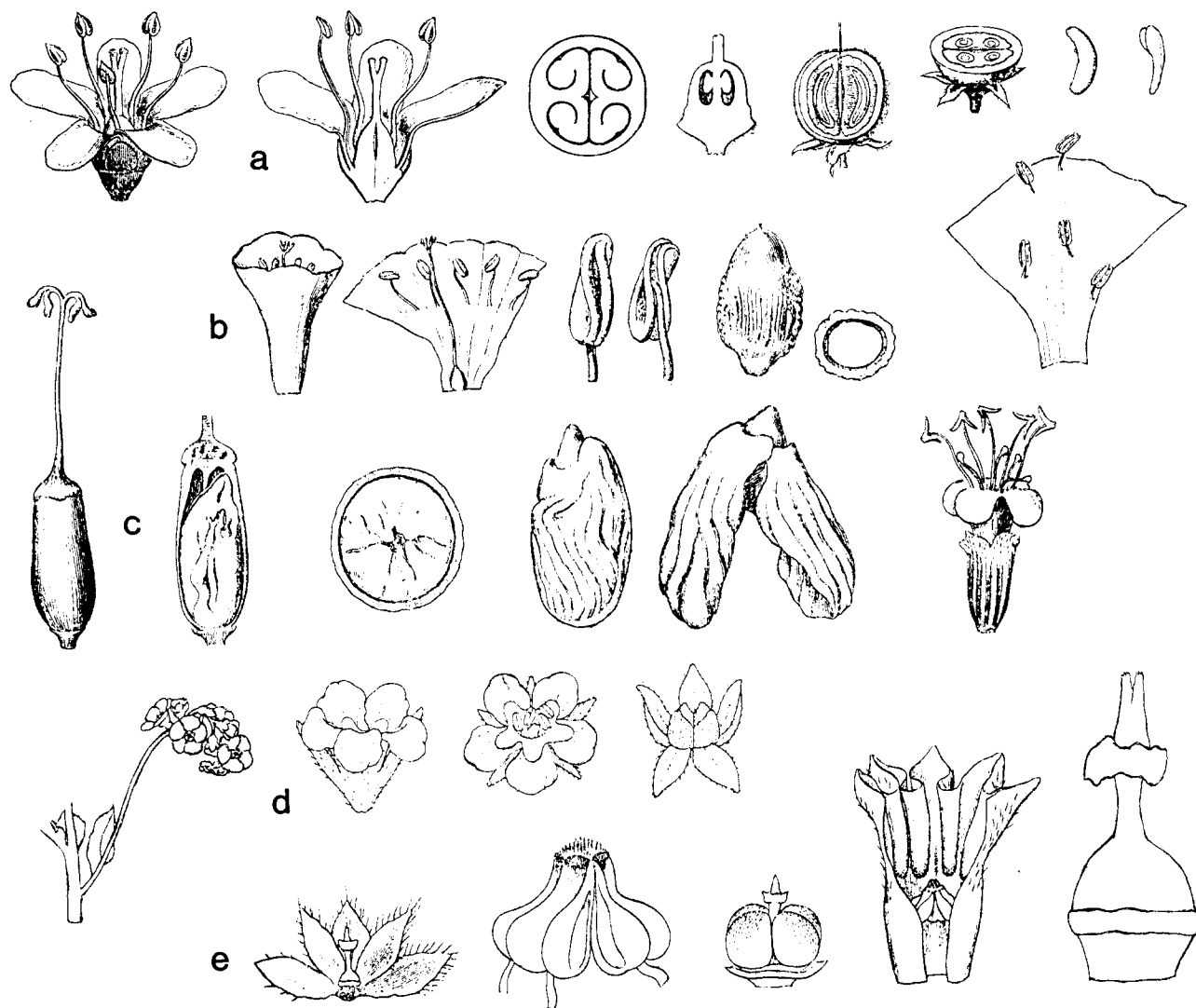


FIGURE 153.—BORAGINACEAE: *a*, *Ehretia serrata* flower, l.s. of same, c.s. of ovary, *E. elliptica* l.s. of ovary, l.s. and c.s. of fruit, seed, embryo; *b*, *Cordia calocephala* corolla, same laid open, views of anther, fruit, c.s. of same, *C. leucocalyx* part of corolla laid open to show insertion of stamens; *c*, *C. excelsa* pistil, l.s. and c.s. of ovary, embryo, same opened, *C. trachyphylla* flower; *d*, *Cynoglossum amabile* part of inflorescence, *Antiphytum cruciatum* flower, same opened, fruit and calyx; *e*, *Heliotropium clauseni* pistil and calyx, coherent anthers, fruit, corolla opened to show position of anthers, pistil (after Baillon, 1866–1895; Sargent; Martius, 1840–1906; Smith, 1970).

terminal tendril, exstipulate, very rarely stipulate; flowers bisexual, zygomorphic, less commonly actinomorphic; sepals 5–4 (2–6), usually connate, the calyx rarely truncate, bilabiate or spathaceous; petals 5–4 (6–8), connate, the corolla regular or often bilabiate, sometimes

spurred, gibbous, ventricose, saccate, personate, campanulate or funnelform; stamens 4–5 (2–8), epipetalous, equal or often didynamous, rarely connate in pairs; sometimes 1–3 staminodes present; anthers basifixed or dorsifixed, sometimes connivent or connate in pairs or in a group of 4,

usually 2-locular, sometimes 1 locule reduced, sometimes the loculi divaricate; pollen 2–13-colpate or -colporoidate, less often 6-rugate, 4-rupate, zone- or spiraperturate, polyforate, 2–4-porate, or nonaperturate; glandular disk usually surrounding the base of the ovary; pistil 1, the carpels 2 (3–5), style 1, usually elongate, the stigma(s) apical; ovary superior, rarely semi-inferior or inferior, 2–1(–5)-locular, the locules sometimes incomplete, ovules often numerous, sometimes few to 1 per locule, more commonly axile than parietal, rarely basal-axile, basal, or subapical, unitegmic, tenuinucellar; fruit a septicidal, loculicidal or infrequently circumscissile capsule or berry, uncommonly nutlets or a drupe, the seeds often numerous, minute, and sculptured, sometimes winged; embryo straight, arcuate or bent, often elongate, the cotyledons narrow or broad, minute and undifferentiated in Orobanchaceae; endosperm copious to absent.

Distribution: Cosmopolitan, in various habitats.

Chemistry: Solanaceae is known for its alkaloids. Aucubin (iridoid) occurs in Scrophulariaceae, Buddlejaceae, Globulariaceae, Bignoniaceae, Lentibulariaceae, and Pedaliaceae(?). Orobanchin is present in Buddlejaceae, Gesneriaceae, Orobanchaceae, and Verbenaceae but not Solanaceae or Lamiaceae. Catalpinoside and stachyose occur in *Catalpa* and *Paulownia*; the latter is also present in some Scrophulariaceae. Plantaginaceae has verbascase, present in at least 2 species of Scrophulariaceae; it also has aucubin (iridoid) glycosides. Gibbs believes Buddlejaceae seems to fit well in the Tubiflorae.

SOLANACEAE (Figure 154a–e).—Herbs, shrubs, small trees, and lianas; xylem vessel perforation plates simple, intraxylary phloem present; leaves alternate, rarely opposite (*Sclerophyllax*), sometimes an opposite pair beneath the inflorescence, simple, entire, lobed, rarely toothed or dissected, exstipulate; inflorescences axillary cymes, dichasia, sometimes cincinni, or the flowers solitary; flowers bisexual, mostly actinomorphic, rarely zygomorphic; sepals 5 (4–6), connate; petals 5 (4–6), connate, plicate, con-

torted or rarely valvate, variously shaped; stamens 5 (2, 4, 6), inserted on the corolla, alternipetalous, usually equal and all fertile, rarely differing in length, rarely only 2 or 4 fertile and didynamous, then a staminode sometimes present; anthers basifixed or dorsifixed, often connivent, the loculi parallel, dehiscence longitudinal or poricidal; pollen 3–5 (2–6)-colpate, -colporoidate, -colporate or rugor(oid)ate or nonaperturate; disk surrounding the base of the ovary; pistil 1, the carpels 2 (3–5), style 1, the stigma apical, capitate or very shortly 2(–5)-lobed; ovary superior, the locules 2 (1–5), the ovules usually numerous (2–4 in *Henoonia*, *Sclerophyllax*), axile, unitegmic, tenuinucellar, anatropous, semi-anatropous, or campylotropous; fruit a septicidal, rarely circumscissile capsule or berry, rarely a drupe (*Grabowskia* has 4 pyrenes); seeds usually numerous, rarely 1–2 (*Henoonia*, *Sclerophyllax*, *Lycium*, *Cestrum*), minute, often sculptured; embryo arcuate, coiled or rarely straight, 0.8–3.0 times the length of the endosperm; cotyledons 1–3 times the width of the radicle, 0.2–0.6 the length of the embryo; endosperm copious, moderate, scanty or 0 (Goetzeinae), fleshy and semi-transparent.

Composition: 90 genera, ~2300 species.

Distribution: Cosmopolitan except the arctic and cool temperate regions of the Northern Hemisphere; mainly tropical and subtropical; centered in South America.

NOLANACEAE (Figure 154f,g).—Herbs or small shrubs; xylem vessel perforation plates simple; intraxylary phloem present; leaves alternate, sometimes paired where branches meet, simple, entire, exstipulate; flowers usually solitary, axillary, sometimes in a raceme, bisexual, actinomorphic; sepals 5, connate; petals 5, connate, the corolla campanulate or funnellform, plicate in bud; stamens 5, equal or 3 long and 2 short, inserted low on the corolla, alternipetalous; anthers about as long as wide or oblong, the sacs slightly divergent basally; pollen 3-colporate; disk surrounding the base of the ovary, sometimes lobed; pistil 1, the carpels typically 5, style 1, the stigma capitate or obscurely 2–5-lobed; ovary

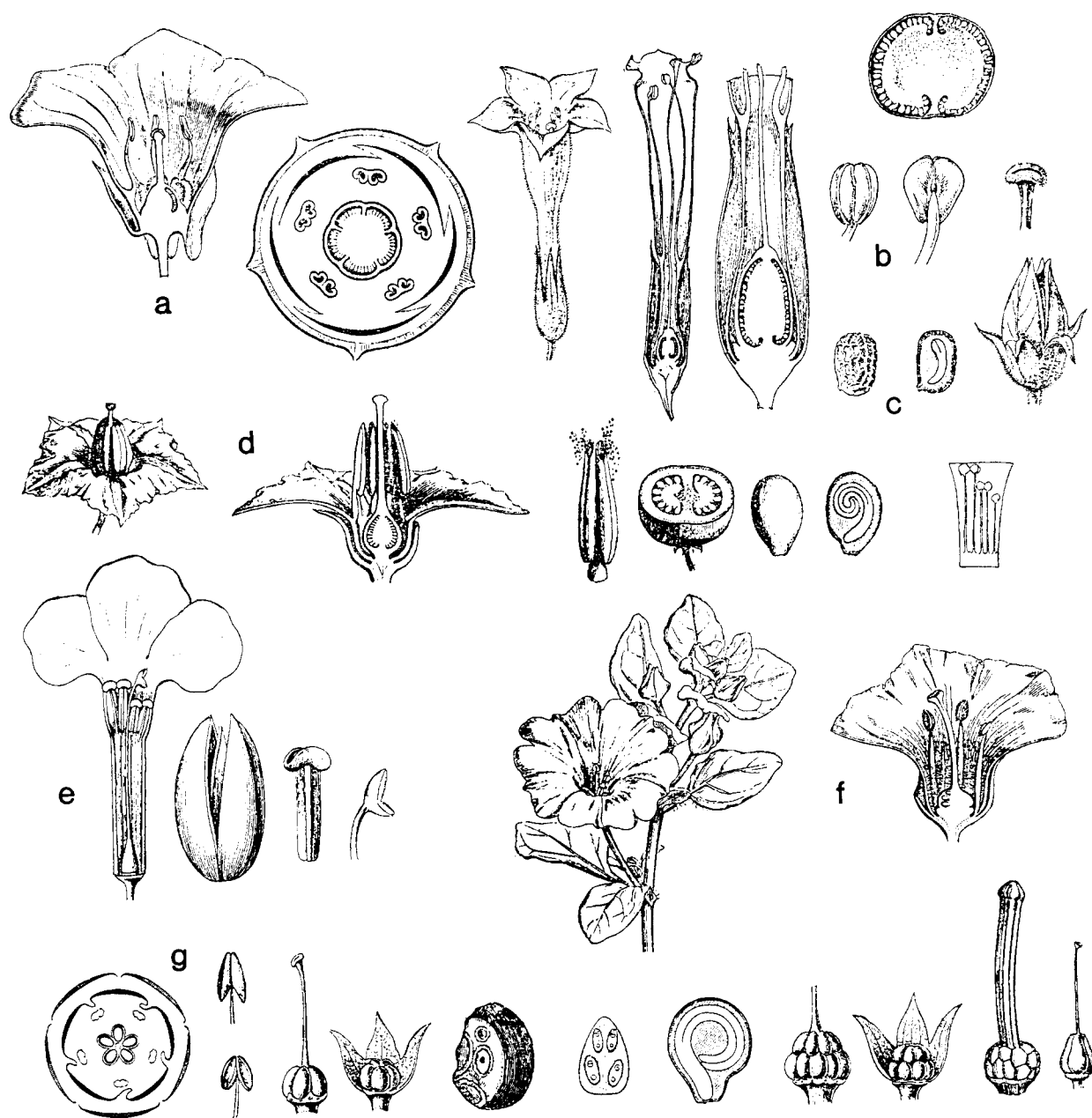


FIGURE 154.—SOLANACEAE: *a*, *Nicandra physaloides* l.s. of flower, floral diagram, *Nicotiana tabacum* flower, *N. glauca* l.s. of flower, l.s. of lower part of flower, c.s. of ovary; *b*, views of anther, *N. tabacum* stigma; *c*, seed, l.s. of same, dehiscent capsule; *d*, *Solanum tuberosum* flower, l.s. of same, anther, c.s. of fruit, seed, l.s. of same, *Petunia axillaris* part of corolla laid open showing different lengths of stamens; *e*, *Brunfelsia obovata* l.s. of corolla showing pistil and stamens, dehiscent fruit, stamen, stigma (after Baillon, 1866–1895; Johnson; von Wettstein, 1935; Smith and Downs; Martius, 1840–1906). NOLANACEAE: *f*, *Nolana paradoxa* flowering shoot, *Alona coelestis* l.s. of flower; *g*, *Nolana prostrata* floral diagram, views of anther, pistil, fruit, drupelet, l.s. of same showing sections of 4 seeds, l.s. of seed, *N. rupestris* base of style and ovary, fruit, *N. atriplicifolia* pistil, *Alona phyllifolia* pistil (after Le Maout and Decaisne, 1873; Baillon, 1866–1895; von Wettstein, 1935).

superior, 5-locular, the ovules 4–1 per locule, basal-axile, unitegmic, tenuinucellar, semi-anatropous; fruit a schizocarp of 3 to ∞ nutlets, the endocarp sometimes stony; embryo terete, arcuate or coiled, 1.6 times the length of the endosperm or longer; cotyledons as wide as the radicle, 0.6–0.7 the length of the embryo; endosperm copious or scanty.

Composition: 2 genera, 80 species.

Distribution: Mostly along the seashore; temperate and subtropical Chile and Peru.

SCROPHULARIACEAE (Figure 155a–d).—Herbs and shrubs, rarely small trees or lianas or green-leaved root parasites; xylem vessel perforation plates simple; intraxylary phloem absent; leaves alternate, opposite or rarely verticillate, simple, usually toothed, sometimes entire or dissected, exstipulate; inflorescences axillary or terminal spikes, racemes, panicles, or cymes and then usually dichasia, or the flowers solitary; flowers bisexual, zygomorphic or rarely nearly actinomorphic; sepals 5 (4–8), usually shortly connate; petals 5 (4–8), very rarely 0 (*Besseyia* spp.), connate, the corolla often bilabiate, sometimes spurred, gibbous or saccate, the lobes imbricate in bud; stamens inserted on the corolla, usually 4, didynamous, often 2 (3–8), one staminode sometimes present; anthers sometimes connivent in pairs, the sacs often divergent basally or sometimes united or reduced to 1, dehiscence longitudinal, rarely poricidal; pollen 2–7-colpate, -colporoidate, or -colporate, occasionally spiraperturate or \pm irregular; disk at the base of or below the ovary, annular or to one side, sometimes lobed; pistil 1, the carpels 2 (3), style 1, the stigmas 2, flattened, or 1 and capitate, apical; ovary superior, bilocular, rarely unilocular (*Rehmannia*), the ovules numerous, rarely few or 1 per locule (Selagineae), axile, unitegmic, tenuinucellar, anatropous, semi-anatropous or rarely campylotropous; fruit a capsule, usually septicidal, sometimes loculicidal or poricidal, very rarely a berry or nutlet (Selagineae, *Tetrachondra*); seeds usually minute, usually numerous, often sculptured; embryo straight or slightly arcuate, often terete, 0.4–1.0 the length of the

endosperm; cotyledons 1–3 times the width of the radicle, sometimes thick, 0.1–0.6 the length of the embryo; endosperm copious or scanty, rarely 0, fleshy.

Composition: 200 genera, 3000 species.

Distribution: Cosmopolitan; centered in the North Temperate Zone; mainly in mountains in the tropics, poorly represented in rain forest.

BUDDLEJACEAE (Figure 156a,b).—Trees and shrubs, very rarely herbs, indument when present glandular, stellate or lepidote; xylem vessel perforation plates simple; intraxylary phloem absent; leaves opposite or verticillate, very rarely alternate, entire or toothed, sometimes stipulate; inflorescences thyrses, racemes, spikes, heads or cymes; flowers bisexual, actinomorphic or slightly zygomorphic; sepals 4 (5), connate; petals 4 (5), connate, imbricate; stamens 4 (5?), inserted on the corolla; anthers longer than wide, the sacs not, or slightly separate, parallel; pollen usually 3 (4)-colporate (-colporoidate) or 4-ruporate; disk sometimes present; pistil 1, the carpels 2, style 1, the stigma enlarged, shortly bilobed; ovary superior, bilocular, sometimes incompletely so, rarely 4-locular, the ovules numerous, axile, unitegmic, tenuinucellar, semi-anatropous; fruit usually a septicidal capsule, rarely a drupe or berry, the seeds minute, often winged or produced at each end; embryo straight, 0.5 the length of the endosperm; cotyledons not broadened, 0.4 the length of the embryo; endosperm moderate, copious or scanty.

Composition: 8 genera, 150 species.

Distribution: Tropical to warm temperate; centered in eastern Asia; southwestern United States to warm temperate South America; Madagascar, tropical, southern, and eastern Africa to southern Arabia, India, eastern and southern Asia to the East Indies.

GLOBULARIACEAE (Figure 156c).—Small shrubs or herbs; xylem vessel perforation plates simple; leaves alternate, often also in a rosette, simple, entire, exstipulate; inflorescences terminal, sometimes also axillary, usually involucre, chaffy heads or dense spikes; flowers bisexual, zygomorphic; sepals 5, connate; petals 5, con-

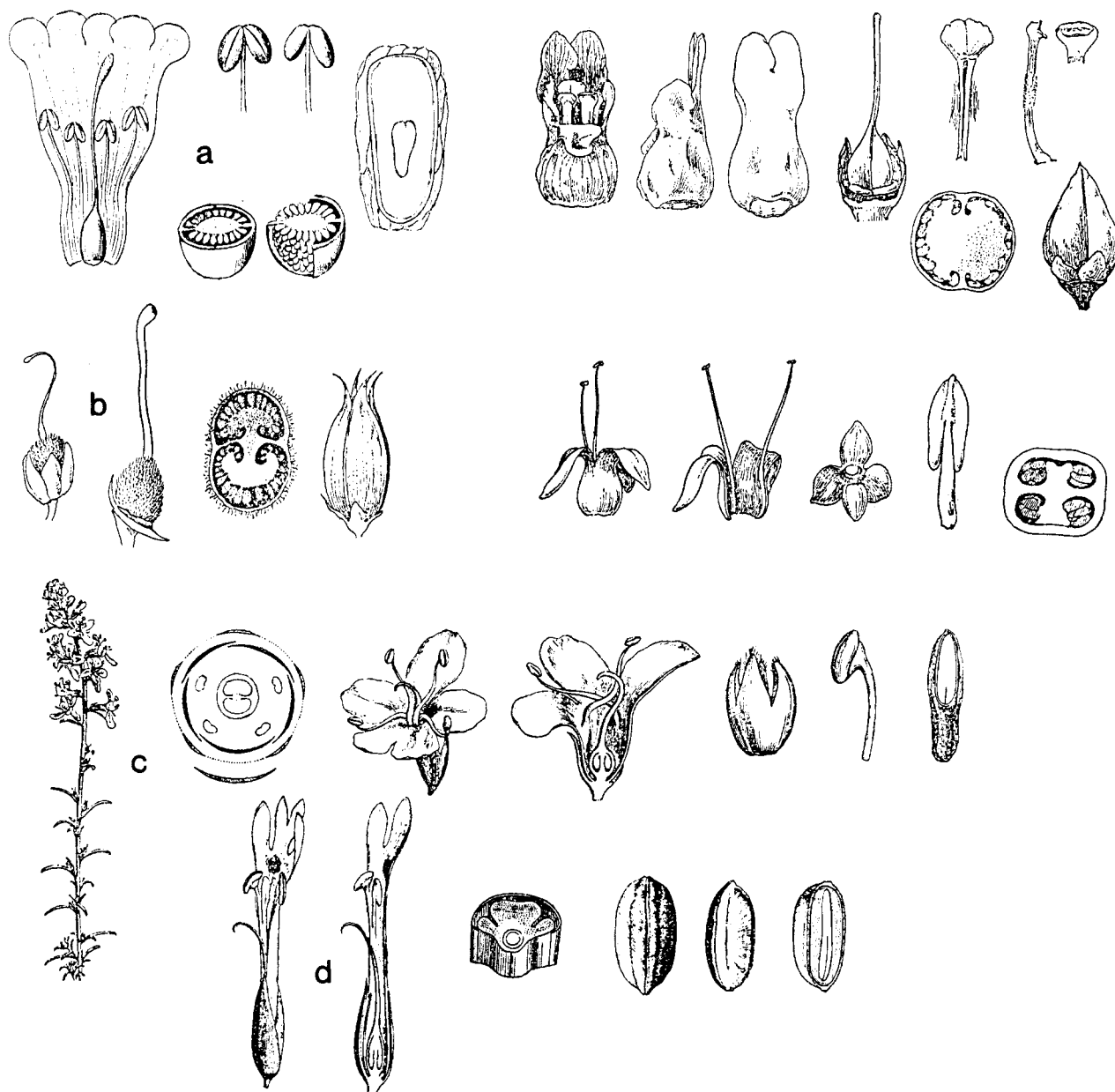


FIGURE 155.—SCROPHULARIACEAE: *a*, *Gerardia communis* corolla laid open showing stamens and pistil, views of anther, sections of fruit, l.s. of seed, *Scrophularia leporella* 3 views of corolla, pistil and hypogynous disk and part of calyx, staminode, upper part of style, stigma, c.s. of ovary, fruit, and calyx; *b*, *Penstemon* sp. pistil and calyx, pistil, c.s. of ovary, dehiscent fruit, *Veronica buxifolia* corolla and stamens, l.s. of corolla, face view of corolla, stamen, c.s. of ovary; *c*, *Selago corymbosa* flowering shoot, floral diagram, *S. stricta* flower, l.s. of same, *S. cinerea* calyx, stamen, *S. corymbosa* l.s. of seed; *d*, *Hebenstretia dentata* flower, l.s. of same, c.s. of fruit, 2 views of seed, l.s. of same (after Martius, 1840–1906; Johnson; Baillon, 1866–1895; Le Maout and Decaisne, 1873).

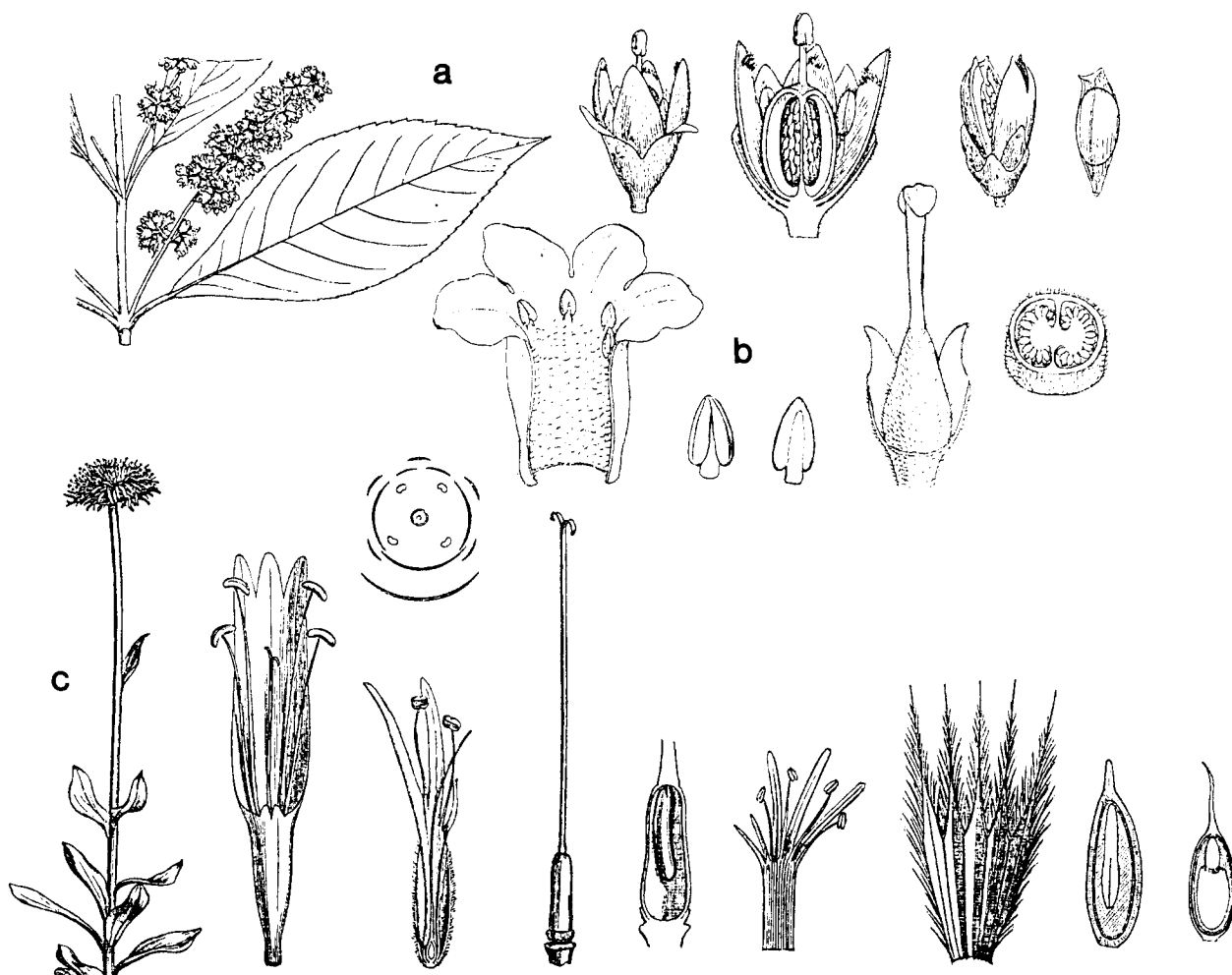


FIGURE 156.—BUDDLEJACEAE: *a*, *Buddleja americana* flowering twig, flower, l.s. of same, dehiscent fruit, seed; *b*, *B. colvilei* corolla laid open, views of stamen, pistil and part of calyx, c.s. of ovary (after Rendle, 1938; Hooker and Hooker, 1837–1982). GLOBULARIACEAE: *c*, *Globularia vulgaris* flowering shoot, flower without calyx, floral diagram and l.s. of flower, pistil, l.s. of ovary, corolla laid open showing insertion of stamens, calyx laid open, l.s. of seed in 2 planes (after Le Maout and Decaisne, 1873; Baillon, 1866–1895).

nate, the corolla bilabiate, the upper lip bilobed to completely reduced, the lower lip trilobed, the lobes imbricate in bud; stamens 4 (2), didynamous, epipetalous, the anthers dorsifixed, dehiscent by a single slit; pollen (2)3-colporate; disk hypogynous, annular, or an anterior gland, or 0; pistil 1, the carpels 2, style 1, elongated, the stigmas 2, acute, or 1 and capitate; ovary superior, unilocular at maturity, the ovule 1, subapical, unitemic, tenuinucellar, anatropous; fruit a nutlet, the pericarp membranous; embryo

straight, often terete, 0.8–0.9 the length of the endosperm, the cotyledons 0.5–0.7 the length of the embryo, 1–2 times as wide as the radicle; endosperm moderate to copious, fleshy.

Composition: 2 genera, 30 species.

Distribution: Centered in the Mediterranean region, extending into most of Europe and to the Caspian Sea; northeastern Africa.

LENTIBULARIACEAE (Figure 157*a,b*).—Herbs of wet habitats; xylem usually much reduced; leaves alternate, often in basal rosettes, or re-

duced to scales, sometimes with bladders, insectivorous, the submersed sometimes finely dissected, exstipulate; inflorescence a scapose raceme or spike or the flower solitary; flowers bisexual, zygomorphic; sepals 5 or 4, free or shortly connate, in 1 or 2 series or united to form 2; petals 5, connate, the corolla spurred, gibbous or personate, the lobes imbricate; stamens 2, inserted on the base of the corolla, sometimes 2 staminodes present; anthers basifixed or dorsifixed, 1–2-locular, the loculi divaricate; pollen apertures 3–18-colporate or colpoidate, occasionally ruplicate or \pm irregular; disk absent; pistil 1, the carpels 2, style 1, short, or the stigma sessile, 2–1-lobed; ovary superior, unilocular, the ovules numerous or rarely 2, basal, unitegmic, tenuinucellar, anatropous; fruit a capsule, dehiscent by 2 or 4 valves or circumscissile, rarely an achene, the seeds numerous, rarely 1, sculptured; embryo straight, the cotyledons as wide as the radicle(?), 0.2–0.4 the length of the embryo; endosperm 0.

Composition: 4 genera, ~200 species.

Distribution: Cosmopolitan.

OROBANCHACEAE (Figure 157c).—Chlorophyllless herbs parasitic on roots; xylem vessel

perforation plates simple; leaves alternate, reduced to scales, exstipulate; inflorescence a terminal raceme or spike or the flower solitary; flowers bisexual, zygomorphic, some cleistogamous; sepals (2) 4–5, connate; petals 5, connate, the corolla bilabiate or nearly regular, the lobes imbricate in bud; stamens 4, didynamous, inserted on the corolla, a staminode present or absent; anthers often connivent in pairs; pollen apertures 3-colpoidate, 3-colp(oro)idate, or \pm irregular; pistil 1, the carpels 2 (3), style 1, elongated, the stigma apical, capitate or 2–4-lobed; ovary superior, unilocular (basally bilocular in *Christisonia*), the ovules numerous, parietal, unitegmic, tenuinucellar, anatropous or semi-anatropous, sometimes the placentas meeting in the center of the ovary; fruit a loculicidal capsule dehiscent by 2 valves; seeds minute, numerous, sculptured; embryo minute, globular, undifferentiated, 0.1 the length of the endosperm; endosperm copious, fleshy.

Composition: 13 genera, 150 species.

Distribution: Centered in temperate Eurasia; few species in America, southern Africa, and Australia, few tropical.

ACANTHACEAE (Figure 157d,e).—Herbs, lianas, and shrubs, rarely small trees; xylem vessel perforation plates simple; intraxylary or interxylary phloem sometimes present; leaves opposite, very rarely alternate (*Elytraria*), simple, usually entire, sometimes lobed and spiny, exstipulate; inflorescences axillary dichasia or monochasia, sometimes a terminal raceme or the flowers solitary; flowers bisexual, zygomorphic, nearly regular in Thunbergioideae; bracts often colored and conspicuous; sepals 4–5 (3), sometimes truncate (*Thunbergia*); petals 4–5, connate, the corolla bilabiate, rarely unilabiate, the lobes imbricate or contorted in bud; stamens 4, didynamous or equally long, sometimes 2, rarely 5 (*Pentstemonacanthus*), inserted on the corolla, the filaments free or partially connate in pairs; 1–3 staminodes frequently present; anthers 2–1-locular, the loculi confluent or separate, basifixed or dorsifixed; pollen 3–9-colpate, 3-colpoidate, 2–4-porate, zone- or spiraperturate; disk below

FIGURE 157.—LENTIBULARIACEAE: a, *Utricularia flaccida* calyx, corolla, *U. tricolor* stamens, *U. flaccida* l.s. of fruit, *U. cornuta* face of flower, a view of stamens and pistil, another view of pistil and 1 stamen, 2 views of pistil; b, stigma, l.s. and c.s. of ovary, habit showing bladders, *Polypomopholix laciniata* calyx, *Genlisea ornata* calyx, *Utricularia cucullata* seed (after Johnson; Martius, 1840–1906). OROBANCHACEAE: c, *Orobanche ramosa* flowering plant attached to host, flower, l.s. of same, dehiscent fruit, seed, *O. eryngii* floral diagram, stamen, *O. hederæ* l.s. of seed (greatly enlarged) showing the minute embryo in copious endosperm (after Baillon, 1866–1895; Le Maout and Decaisne, 1873; Beck). ACANTHACEAE: d, *Arrhoxylon glabrum* bud, flower, l.s. of corolla showing insertion of stamens, views of anther, pistil, and calyx; e, *Justicia longepetiolata* views of anther, stigma, fruit and calyx, fruit with calyx removed, valves of fruit with and without seeds, seed (after Martius, 1840–1906). BIGNONIACEAE: f, *Cybistax antisiphilitica* flower, l.s. of same, corolla laid open showing the stamens and staminode, floral diagram, stigma, l.s. of ovary and disk, l.s. of seed showing embryo, part of dissepiment (above) and part of dehiscent fruit (after Martius, 1840–1906).

the ovary, sometimes annular or cupular; pistil 1, the carpels 2, style 1, elongated, the stigmas 2, one often smaller than the other; ovary superior, bilocular (1-locular in *Elytraria* and *Mendoncia*), the ovules 2 (1–10) per locule, axile (parietal in *Elytraria*), unitegmic, the integument thick, tenuinucellar, anatropous, campylotropous or amphitropous; fruit a loculicidal capsule, rarely a drupe (*Mendoncia*), the seeds few, funicle usually indurate; embryo large, the cotyledons usually foliose and thin, sometimes moderately thick, usually slightly to markedly bent, 0.9 the length of the endosperm, 3.5–9.0 times wider than the radicle, 0.7–0.9 the length of the embryo, the radicle sometimes invested; endosperm usually 0, sometimes moderate (Nelsonioideae) or scanty, fleshy.

Composition: 250 genera, 2600 species.

Distribution: Various habitats; mainly pantropical, centered in southeastern Asia, Africa, and tropical America; few temperate; United States to warm temperate South America.

BIGNONIACEAE (Figure 157f).—Trees, shrubs, and lianas, very rarely herbs; xylem vessel perforation plates typically simple, but with a few multi-perforate plates in some genera; interxylary phloem sometimes present; leaves opposite, rarely alternate or verticillate, mostly compound, sometimes simple, often toothed, sometimes entire, sometimes the terminal leaflet(s) converted to a branched tendril, exstipulate; inflorescences usually dichasia, sometimes tending to become cincinnal, sometimes a panicle, or the flowers solitary; flowers bisexual, somewhat zygomorphic, sometimes nearly actinomorphic; sepals 5, connate, the calyx 5-toothed, rarely truncate or bilabiate; petals 5 (sometimes 6–7 in *Catophractes*), connate, the corolla usually campanulate or funnellform, the lobes imbricate in bud, rarely valvate; stamens 4, didynamous, or 2 (5–7), inserted on the corolla; staminodes 1 or 3; anthers usually connivent in pairs, the sacs divergent 180° (only 1 sac of each anther fertile in *Millingtonia*); pollen 3-colporoidate, nonaperturate, 2–12-colpate, 4-rupate, 6-rugate or spiraperturate; disk usually present, hypogynous, annular

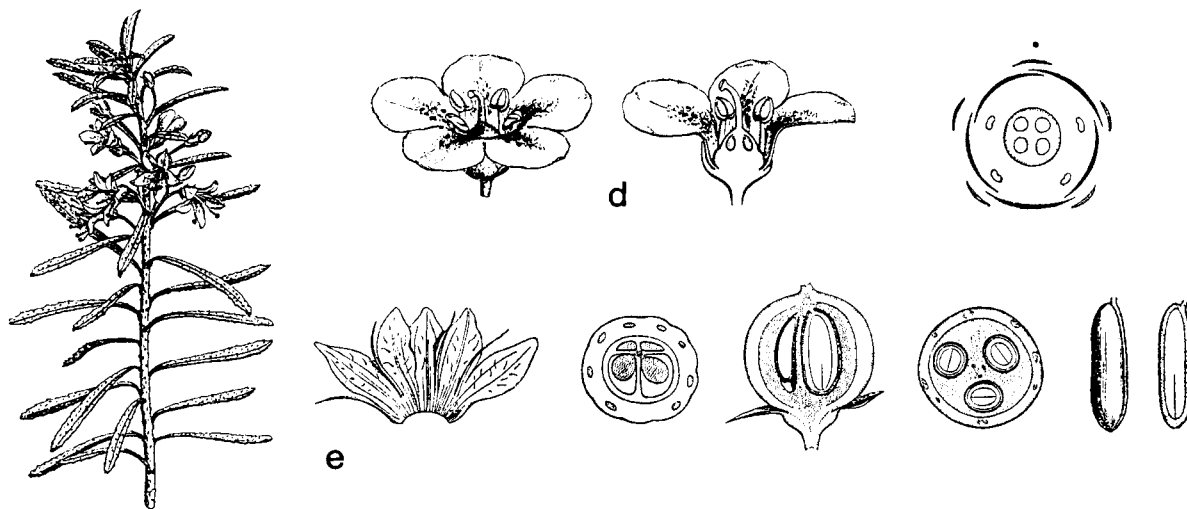
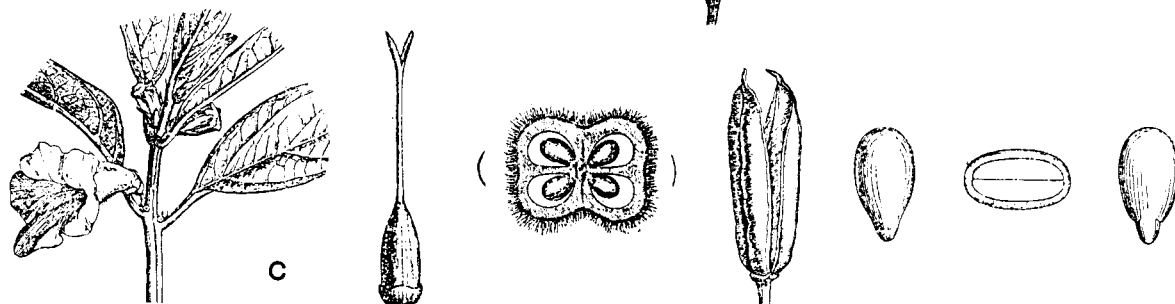
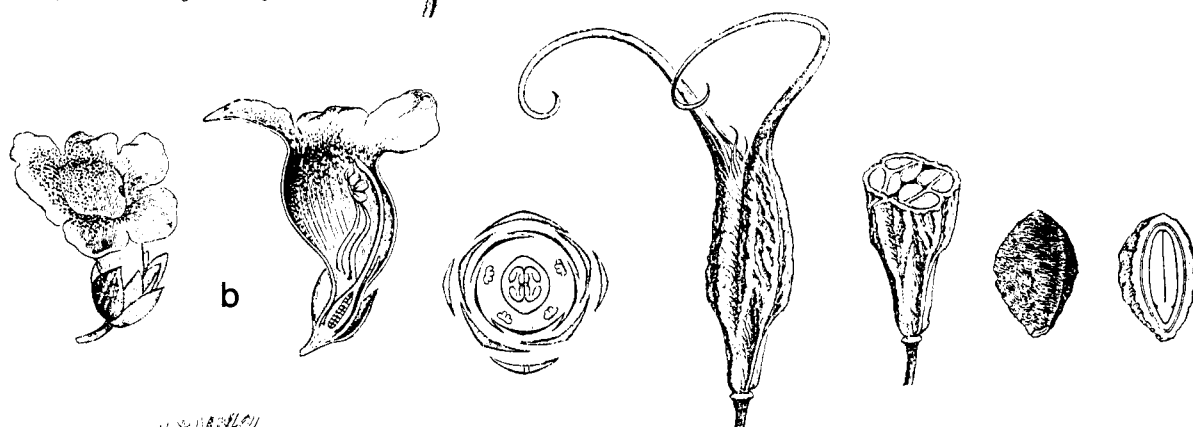
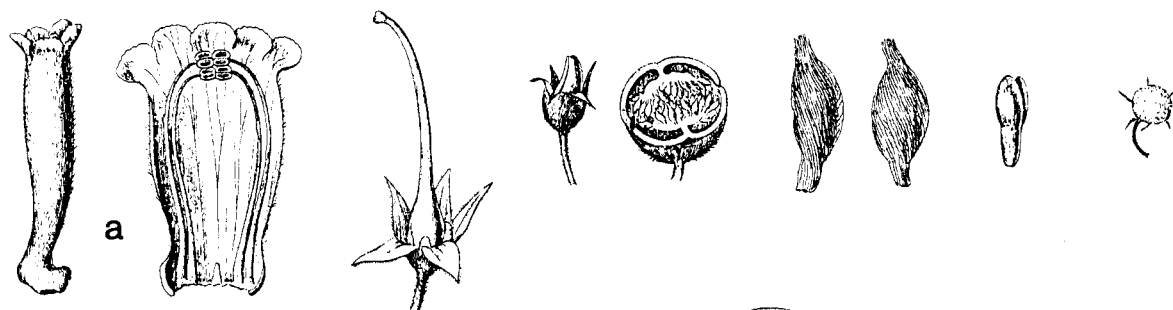
or cupular; pistil 1, the carpels 2, style 1, the stigma apical, bilobed, ventrally papillose; ovary superior, bilocular, rarely 1- or 4-locular, the ovules numerous, axile or rarely parietal, unitegmic, tenuinucellar, anatropous or semianatropous; fruit an often elongated loculicidal or septicidal capsule, or a large berry with a hard surface; seeds numerous, rarely few (*Argylia*), often flattened and winged; cotyledons spread out, straight, large, thin, rarely thick (*Argylia*), 3–4 times wider than the radicle, 0.8 the length of the embryo, the radicle invested; endosperm 0.

Composition: 120 genera, 700 species.

Distribution: Mainly pantropical, few temperate America and Africa; centered in tropical South America.

GESNERIACEAE (Figure 158a).—Herbs, shrubs, or rarely small trees or lianas, many epiphytes; xylem vessel perforation plates simple; leaves opposite, rarely alternate or whorled, sometimes radical, simple, entire or toothed, rarely pinnatisect, exstipulate; inflorescences usually cymose, sometimes racemose, or the flowers solitary; flowers bisexual, usually zygomorphic, rarely nearly actinomorphic (*Ramonda*); sepals 5 (4–6), free or basally connate; petals 5 (4–6), connate, the corolla often bilabiate, often ventricose, rarely spurred, the lobes imbricate in bud; stamens 4, didynamous, rarely equal, or 2, rarely 5 (*Ramonda*, *Sinningia* spp.), inserted on the corolla, often near the base; sometimes 1 or 3 staminodes present; anthers connate or connivent in pairs or in a group of 4, rarely free,

FIGURE 158.—GESNERIACEAE: *a*, *Sinningia pendulina* corolla, same laid open showing the stamens and staminode, pistil with hypogynous glands and calyx, fruit and calyx, c.s. of fruit, views of seed, embryo, *Codonanthe devosiana* fruit (after Martius, 1840–1906). PEDALIACEAE: *b*, *Martynia lutea* flower, l.s. of same, floral diagram, fruit, c.s. of same, seed, l.s. of same; *c*, *Sesamum orientale* flowering shoot, pistil, c.s. of ovary, dehiscent fruit, seed, c.s. of same, embryo (after Baillon, 1866–1895; Le Maout and Decaisne, 1873). MYOPORACEAE: *d*, *Myoporum acuminatum* flower, l.s. of same, *M. parviflorum* floral diagram; *e*, flowering twig, corolla laid open, c.s. of ovary, l.s. and c.s. of fruit, seed, l.s. of same (after Baillon, 1866–1895; Le Maout and Decaisne, 1873).



bilocular; pollen 3 (2–4)-colporoidate or colpate, occasionally 4-ruporoidate or 6-rugoroidate; disk annular or cupular or of separate glands or scales, or to one side of the ovary, rarely absent; pistil 1, the carpels 2, style 1, elongated, stigma apical, simple and capitate or bilobed; ovary superior, semi-inferior or inferior, unilocular, rarely bilocular or incompletely 2- or 4-locular, rarely only 1 carpel fertile (*Hemiboea*), the ovules numerous, usually parietal, rarely axile, unitegmic, tenuinucellar, anatropous; fruit a 2- or 4-valved, usually loculicidal, rarely septicidal (*Ramonda*) or circumscissile, often elongated capsule, or a hard or soft berry; seeds numerous, minute, sculptured; embryo straight, 0.8–0.9 the length of the endosperm; cotyledons as broad as the radicle, 0.3–0.5 the length of the embryo; endosperm copious or moderate, rarely 0.

Composition: 125 genera, 1,800 species.

Distribution: Mostly pantropical in cloud forest, few in temperate South America, Africa, Australia, New Zealand, and Eurasia.

PEDALIACEAE (Figure 158*b,c*).—Herbs, rarely shrubs or small trees; xylem vessel perforation plates simple; leaves opposite or alternate, simple, usually irregularly lobed and toothed, sometimes entire, exstipulate; inflorescences axillary cymes or solitary flowers, or terminal racemes; flowers bisexual, zygomorphic; sepals 5, connate or sometimes nearly free, sometimes spathaceous or bilabiate; petals 5, connate, the 5 lobes imbricate in bud, the corolla sometimes ventricose or spurred; stamens 4 and didynamous, or 2 (*Trapella*), inserted on the corolla; staminodes 1–2; anthers often connivent, the sacs parallel and dorsifixed, or divaricate; pollen 5–13-colpate, -colporoidate, polyforate, or non-aperturate; disk annular, hypogynous; pistil 1, the carpels 2, style 1, elongated, the stigmas apical, 2 or 1 and punctiform; ovary superior or rarely inferior (*Trapella*), 1–2- or 4-locular, the ovules 1 to numerous per locule, axile or parietal, unitegmic, tenuinucellar, anatropous; fruit a loculicidal capsule, nut or subdrupe, often horned, hooked, or winged; seeds 1–many, sometimes sculptured; embryo straight, 0.9–1.0 the length of the en-

dosperm; cotyledons moderately thick, 2–2.8 times wider than the radicle, 0.6–0.8 the length of the embryo; endosperm scanty or 0.

Composition: 15 genera, 60 species.

Distribution: Tropical and subtropical, few in temperate regions; mostly in dry and coastal habitats; Pedalioideae in most of Africa, part of India, Indochina, the East Indies, and northern Australia; Martynioideae in tropical and subtropical America.

LAMIALES

Shrubs, herbs, trees, and lianas, often with marked characteristic aromatic fragrances; xylem vessel perforation plates simple, very rarely also a few scalariform with few bars; intraxylary phloem very rarely present (*Oftia* and *Avicennia*); leaves opposite, rarely alternate, simple, rarely compound, usually toothed, sometimes entire or dissected, often gland-dotted, exstipulate; flowers bisexual, rarely unisexual, mostly zygomorphic; sepals 5–4 (–8), connate, the calyx subactinomorphic or bilabiate; petals 5–4 (–16), connate, the corolla mostly bilabiate, sometimes actinomorphic; stamens 4, 2 (–16), rarely 1–3 staminodal, inserted on the corolla, usually didynamous, the filaments very rarely basally connate (*Coleus*); anthers dorsifixed, the sacs often divaricate, sometimes 1 sac of the anther aborted; pollen 3 (2–5)-colpate, 3-colporate, rarely 3 (4)-colporoidate or 6-rug(or)ate; pistil 1, the carpels 2 (3–5 in *Geunsia*, *Duranta*), style 1, terminal or gynobasic, the stigmas apical; ovary superior, 1–2 (3–5)-locular, the ovules 2 (–8) per carpel, usually basal, rarely axile, very rarely the placenta free-central (*Avicennia*), unitegmic, tenuinucellar; fruit nutlets, drupe, very rarely a capsule; embryo usually straight, nearly as long as the endosperm; endosperm absent or scanty, very rarely moderate.

Distribution: Cosmopolitan, in various habitats.

Chemistry: Verbenaceae and Lamiaceae are chemically very similar. They are rich in monoterpenoids and share a number of terpenoids. Furans occur most often in Lamiaceae and My-

oporaceae, but they are present in several unrelated families too.

MYOPORACEAE (Figure 158*d,e*).—Shrubs or small trees; xylem vessel perforation plates simple; secretory cavities present in the leaf and stem; intraxylary phloem present in *Oftia*; leaves alternate or rarely opposite, simple, entire or toothed, often gland-dotted, exstipulate; inflorescences axillary cymes, or the flowers solitary; flowers bisexual, usually zygomorphic sometimes actinomorphic; sepals 5, connate; petals 5, connate, the corolla subactinomorphic, 5-lobed, to bilabiate, the lobes imbricate in bud; stamens 4, didynamous, rarely 5, inserted on the corolla; sometimes 1–3 staminodes present; anther sacs divergent basally; pollen 3-colpate, 3-colporate, 3 (4)-colporoidate, rarely 6-rugorate; pistil 1, the carpels 2, style 1, elongated, stigma apical, obscurely bilobed; ovary superior, the locules 2 (3–10), ovules 1–8 per locule, axile-apical, unitegmic, tenuinucellar, anatropous; fruit a drupe or 1–8 nutlets; embryo straight or slightly curved, subterete, 0.9 the length of the endosperm; cotyledons plano-convex, as wide as the radicle, 0.4 the length of the embryo; endosperm scanty or 0, fleshy.

Composition: 4 genera, 100 species.

Distribution: Centered in Australia; all Australia, New Zealand, New Guinea; few in eastern China, Japan, and the West Indies.

VERBENACEAE (Figure 159*a–d*).—Shrubs, trees, herbs, and lianas; xylem vessel perforation plates simple except for rare reticulate plates and a few scalariform plates in some species of *Vitex*; intraxylary phloem present in *Avicennia*; leaves opposite or whorled, rarely alternate (some *Chloanthoideae* and *Amasonia*), usually simple, rarely compound, toothed, entire or dissected, exstipulate; inflorescences terminal, rarely axillary spikes, heads, corymbose-paniculate, dichasial cymes with a cincinnal tendency, or the flowers solitary; flowers bisexual, or the plants polygamous, zygomorphic or actinomorphic; sepals 4–5 (–8), connate; petals 4–5 (–16), connate, the lobes imbricate in bud; stamens 4 (2–16), didynamous, inserted on the corolla, rarely 1 or 3

staminodes present; anthers dorsifixed, the sacs often divaricate; pollen 3 (2–5)-colpate, 3-colporate, rarely 6-rugate or 3-colporoidate; disk annular or absent; pistil 1, the carpels 2 (3–5 in *Geunsia*, *Duranta*), style 1, terminal, the stigma usually bilobed, sometimes punctiform (*Stilbe*) or 3–5-lobed (*Geunsia*, *Duranta*); ovary superior, the locules 2 (only 1 fertile in *Stilbe*) (4–5), sometimes incomplete, the ovules unitegmic, tenuinucellar, anatropous or suborthotropous (*Vitex*, *Avicennia*), 1–2 per locule, usually basal, rarely axile, sometimes the placenta free-central (*Avicennia*); fruit a drupe, nutlet(s), rarely a capsule (*Campylostachys*, *Caryopteris*, *Nyctanthes*, *Dimetra*, *Avicennia*); embryo straight, 0.9 to as long as the endosperm if present; cotyledons moderately thick, rarely conferruminate or plicate, 1.3–3.0 times wider than the radicle, 0.5–0.8 the length of the embryo, the radicle rarely invested; endosperm 0 or scanty, rarely moderate (*Avicennia*, *Stilbe*, *Chloanthes*), fleshy.

Composition: 75 genera, 2600 species.

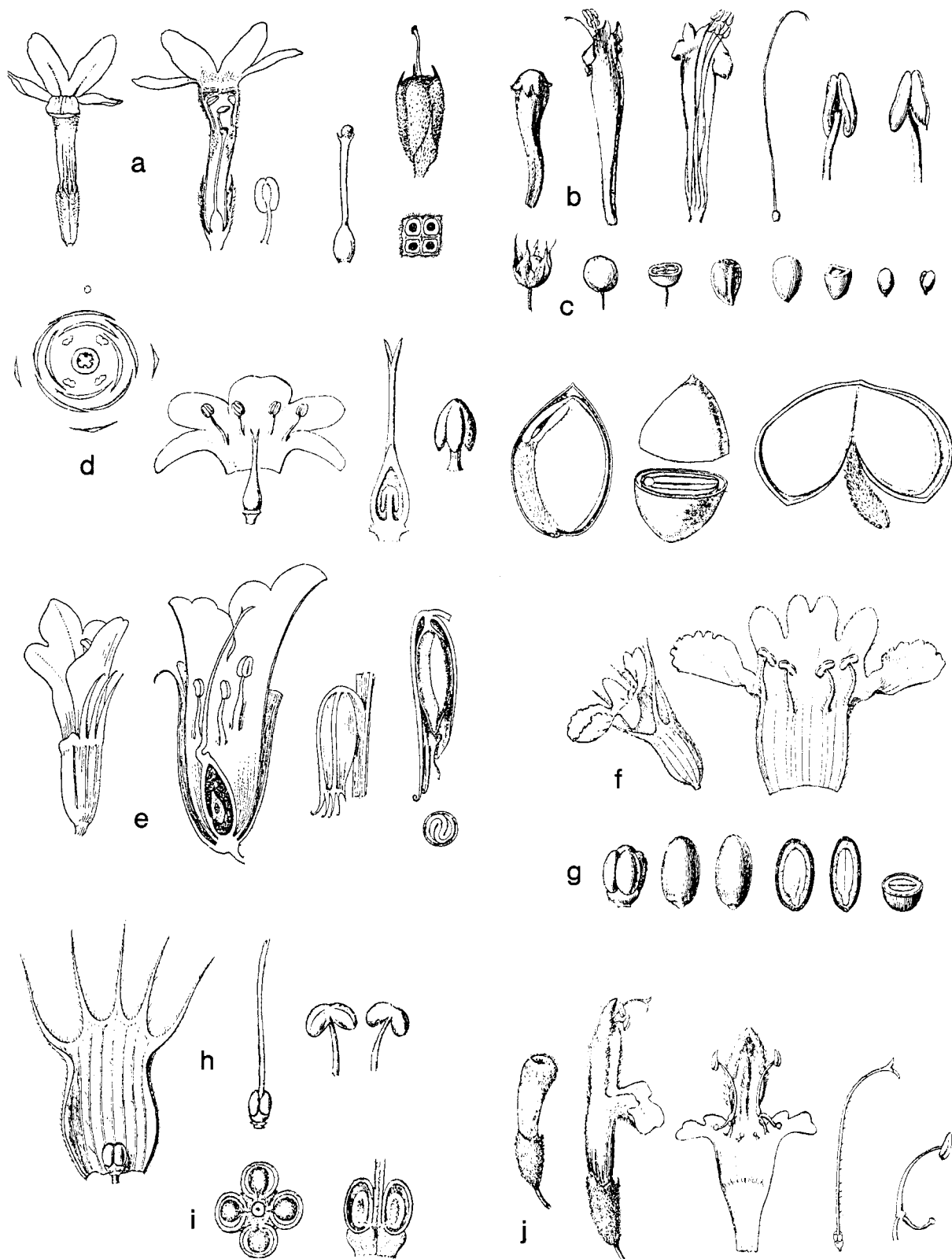
Distribution: Pantropical and subtropical, few in warm temperate zones, lacking in arctic and cool temperate zones.

PHRYMACEAE (Figure 159*e*).—Herbs; xylem vessel perforation plates simple; leaves opposite, simple, toothed, exstipulate; inflorescences terminal and axillary spikes; flowers bisexual, zygomorphic; sepals 5, connate, the calyx bilabiate; petals 5, connate, the corolla bilabiate; stamens 4, didynamous, inserted on the corolla; anthers about as long as wide, the sacs not divergent; pollen 3-colpate; pistil 1, the carpels 2, style 1, terminal, the stigma very shortly bifid; ovary superior, unilocular, the ovule 1, basal, unitegmic, tenuinucellar, suborthotropous; fruit a nutlet, the pericarp membranous; embryo convolute or longitudinally folded, the cotyledons flattened, broad, 0.8 the length of the embryo; endosperm 0.

Composition: 1 genus, 2 species.

Distribution: Temperate eastern Asia and eastern North America.

LAMIACEAE (Figure 159*f–j*).—Herbs, rarely shrubs, very few small trees (*Hyptis*), a few climb-



ers (*Scutellaria*), usually with marked characteristic aromatic fragrances; vessel perforation plates simple, except some scalariform plates with few bars at right angles to their usual direction in *Cymaria elongata*; leaves opposite, rarely whorled, very rarely alternate (*Icomum*), often glandular-punctate, simple, usually toothed, rarely pinnately dissected (*Cedronella*), sometimes entire, exstipulate; inflorescences terminal or axillary, usually a dichasial cyme, becoming cincinnal and glomerate in its later branchings, rarely a raceme, spike or head, rarely the flowers solitary; flowers bisexual, rarely the plants gynodioecious, zygomorphic, rarely subactinomorphic; sepals 5 (4 in *Preslia*), connate, the calyx subactinomorphic or bilabiate; petals 5 (4), connate, the corolla often bilabiate, rarely subactinomorphic; stamens 4, often didynamous, or 2, inserted on the corolla, the filaments separate (basally connate in *Coleus*), sometimes 1–2 staminodes present; anther sacs usually divaricate, sometimes only 1 sac of each anther fertile; pollen usually 3 (4)- or 6-colpate, rarely 3-colporoidate; disk mostly 4- or 2-lobed, often to one side of the ovary; pistil 1, the carpels 2, style 1, usually gynobasic, sometimes terminal, the stigma usually bifid and the branches linear, rarely shortly 4-fid (*Cleonia*); ovary superior, the locules 2, eventually 4-lobed, the ovules 2 per

carpel, basal-axile, unitegmic, tenuinucellar, anatropous or semianatropous; fruit 4 (–1) nutlets, rarely a drupelet (*Stenogyne*, *Gomphostemma*, *Prasium*); embryo usually straight, sometimes bent (*Scutellaria*, *Catopheria*), 0.9 to as long as the endosperm if present; cotyledons moderately thick, or thin, 2.5–5.5 times wider than the radicle, 0.5–0.7 the length of the embryo, the radicle usually invested, rarely accumbent or incurbent on the cotyledons; endosperm usually 0, sometimes scanty (*Prosthathera*), fleshy.

Composition: 180 genera, 3000 species.

Distribution: Cosmopolitan; centered in the Mediterranean region to central Asia, less frequent in the Southern Hemisphere; various habitats, mostly open areas, few in rain forest.

CAMPANULALES

Herbs, rarely shrubs, small trees, or climbers; xylem vessel perforation plates simple, rarely also a few scalariform with few bars; laticiferous canals sometimes present; medullary bundles or intraxylary phloem sometimes present; leaves alternate, rarely opposite or radical, simple, toothed or entire, very rarely lobed, exstipulate; flowers bisexual, very rarely unisexual, actinomorphic or zygomorphic; sepals 5 (3–10, 0), basally connate, rarely free; petals 5 (3–10), connate, very rarely free, the lobes valvate in bud, rarely imbricate, the corolla campanulate, bilabiate or tubular, a paracorolla rarely present; stamens 5 (2–10), free or connate, inserted on the corolla or on a disk, rarely adnate to the style, the anthers basifixed, free or connate, very rarely didymous; pollen 3–10-colpate, 3–6 (2)-colporate, 3 (2)- or 6–7-colporoidate, 4–8-poroid, occasionally 4-rupate, sometimes spinulose; glandular disk usually present; pistil 1, the carpels 2–5 (–10), style 1, sometimes 2–3-fid, elongate, sometimes indusiate, the stigmas apical, sometimes slightly elongate; ovary inferior, semi-inferior, or rarely superior, the locules 2–5 (1–10), ovules numerous to 1, axile, basal or apical, rarely parietal or the placenta free-central, unitegmic, tenuinucellar; fruit a capsule dehiscent by pores, lateral slits, apically, loculicidally, sep-

FIGURE 159.—VERBENACEAE: *a*, *Verbena hastata* flower, 1.s. of same, stamen, pistil, developing fruit invested by calyx and bract and c.s. of same (below); *b*, *Amasonia lasiocaulis* corolla in bud, flower without the calyx, corolla laid open, pistil, views of anther; *c*, calyx and fruit, fruit, c.s. of same, 2 views of a nutlet, c.s. of same, seed, embryo; *d*, *Avicennia nitida* floral diagram, flower laid open, 1.s. of pistil, placental column and ovules, 1.s. and c.s. of fruit, embryo laid open (after Johnson; Martius, 1840–1906; Sargent). PHRYMACEAE: *e*, *Phryma leptostachya* flower, 1.s. of same, calyx (reflexed in fruit), 1.s. of calyx and fruit showing the solitary seed, c.s. of fruit showing folding of the cotyledons (below) (after Johnson, Briquet). LAMIACEAE: *f*, *Hyptis virgata* flower, corolla laid open; *g*, ovary and disk, 2 views of nutlet, 1.s. of same in 2 planes, c.s. of same; *h*, calyx laid open showing ovary, pistil, views of anther; *i*, c.s. and 1.s. of fruit showing gynobasic style; *j*, *Salvia hilarii* bud, flower, corolla laid open showing stamens and staminodes, pistil, stamen (after Martius, 1840–1906).

ticidally or circumscissile, rarely a berry, drupe, nutlet, or achene, the seeds often minute; embryo minute to nearly as long as the endosperm, straight, the cotyledons usually 1–2 times the width of the radicle and up to half the length of the embryo; endosperm usually copious or moderate, rarely absent.

Distribution: Cosmopolitan, in various habitats.

Chemistry: Gibbs says Campanulaceae and Goodeniaceae hang together, but the Asteraceae seem to differ rather markedly from the other members of the order, perhaps enough to warrant separation from it. The chemistry of Campanulales and Cucurbitaceae fits quite well together, but the cucurbitaceous amino-acids, seed-fats and absence(?) of inulin, would all mark off the Cucurbitaceae from the Campanulales.

CAMPANULACEAE (Figure 160*a,b*).—Mostly herbs, a few shrubs and small trees (*Clermontia* spp.), rarely climbers (*Cyphia*); xylem vessel perforation plates simple, but a few scalariform bars in *Platycodon*, *Lightfootia*, *Roëlla*, and *Lobelia*; laticiferous canals present; medullary bundles present in a number of genera; sometimes intraxylary phloem present; glandular hairs absent; leaves simple, alternate, rarely opposite or whorled, toothed (entire in *Sphenoclea*), exstipulate; inflorescences terminal or axillary, rarely epiphyllous (*Ruthiella*), racemes, spikes or heads or cymose, sometimes thyriform or the flowers solitary; flowers usually bisexual, the plants very rarely dioecious, actinomorphic or zygomorphic; sepals 5 (3–10), basally connate, very rarely free, usually adnate to the ovary; petals 5 (3–10, 0 when cleistogamous), connate, rarely free (*Dialypetalum* and 2 other genera), valvate, the corolla campanulate, tubular or bilabiate; stamens 5 (3–10), inserted basally on the corolla or on the disk, the filaments free or connate; anthers free or connate; pollen 4–10-colpate, (2) 3–6-colporate, (2) 3 or 6–7-colporoidate, sometimes spinulose; disk epigynous, sometimes cupular or tubular; pistil 1, the carpels 2–5 (–10), style 1, elongated, the stigmas 2–5 (–10), apical and sometimes slightly elongated; ovary inferior, semi-inferior,

or rarely superior (*Cyananthus*), the locules 2–5 (1–10), the ovules mostly numerous (1 per locule in *Mezleria*), axile, basal or apical, rarely parietal, unitegmic, tenuinucellar, anatropous; fruit a capsule dehiscent by pores or by lateral slits, or apically loculicidal, or circumscissile (*Lysipomia*, *Siphocodon*, *Sphenoclea*), rarely a berry; seeds minute, the embryo straight, 0.1–0.7 the length of the endosperm; cotyledons 1–2 times the width of the radicle, 0.06–0.5 the length of the embryo; endosperm copious or moderate, fleshy.

Composition: 65 genera, 2000 species.

Distribution: Cosmopolitan; Campanuloideae centered in north temperate zone, only one genus being confined to the tropics; few in the Southern Hemisphere but several in South Africa; Lobelioideae centered in America, many tropical, often at higher elevations; southern Canada to the southern tip of South America; southern 2/3 of Africa, Madagascar; Japan, north-eastern Siberia to India, Indochina, the East Indies, Australia, New Zealand; western Europe and the Mediterranean region.

GOODENIACEAE (Figure 160*c,d*).—Herbs and small shrubs; xylem vessel perforation plates simple; laticiferous canals absent; medullary bundles present in 3 genera; leaves alternate or rarely opposite, sometimes rosulate, simple, toothed or entire, exstipulate; inflorescences cymes, racemes, spikes, panicles or heads or the flowers solitary in the leaf axils; flowers bisexual, zygomorphic to subactinomorphic; sepals 5 (3, 0), connate or free; petals 5, connate, the corolla bilabiate or rarely unilabiate, the lobes valvate in bud; stamens 5, free or rarely shortly adnate to the corolla; anthers basifixed, usually free, sometimes connivent or connate around the style; pollen usually 3-colporate, 4–8-poroid, occasionally 4-rupate, sometimes minutely spinulose; pistil 1, the carpels 2, style 1, or 2–3-fid, elongated, indusiate apically, the stigma bilobed; ovary usually inferior, sometimes semi-inferior, 1–2 (4)-locular, the ovules 1 or more per locule, mostly basal, sometimes axile, unitegmic, tenuinucellar, anatropous or campylotropous; fruit a capsule, drupe or nut, the seeds flat, the embryo usually

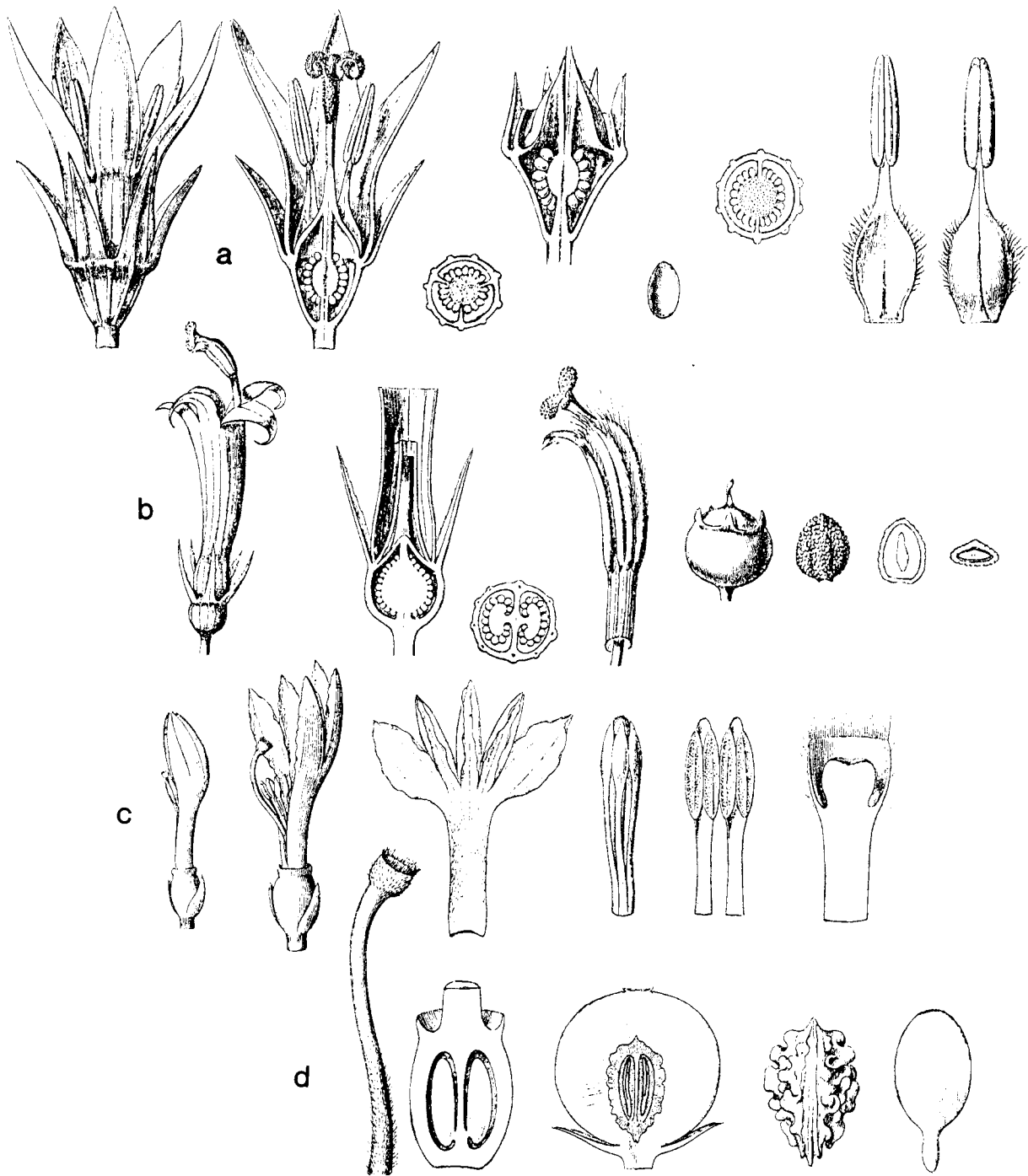


FIGURE 160.—CAMPANULACEAE: *a*, *Wahlenbergia brasiliensis* flower, l.s. of same, c.s. of ovary, l.s. of fruit, seed, *W. linarioides* c.s. of ovary, views of stamen; *b*, *Centropogon surinamensis* flower, l.s. of lower part of same, c.s. of ovary, upper part of staminal tube showing united anthers and stigma, fruit, seed, l.s. and c.s. of same (after Martius, 1840–1906). GOODENIACEAE: *c*, *Scaevola plumieri* bud, flower, corolla laid open, stamens showing anthers in dorsal view, 2 stamens showing anthers in ventral view, stigma surrounded by indusium; *d*, style, l.s. of ovary, l.s. of fruit, pyrene, embryo (after Martius, 1840–1906).

straight, 0.8 the length of the endosperm; cotyledons thin, twice as wide as the radicle, 0.4–0.5 the length of the embryo; endosperm usually copious, sometimes moderate, fleshy.

Composition: 14 genera, 300 species.

Distribution: Centered in Australia, especially the southwest; shores of southeastern Asia, eastern, southern and western Africa, Madagascar, eastern tropical America and temperate western South America.

BRUNONIACEAE (Figure 161*a,b*).—Herb; xylem vessel perforation plates simple; leaves simple, rosulate, entire, exstipulate; inflorescences scapose cymose heads, bracteate; flowers bisexual, subactinomorphic; sepals 5, connate; petals 5, connate, the lobes valvate in bud; stamens 5, the filaments not connate, inserted on the corolla near the base, the anthers basifixed, connate around the style; pollen 3-colporate; pistil 1, the carpels 2, style 1, indusiate apically, the stigma small, not divided; ovary superior, unilocular, ovule 1, basal, unitegmic, tenuinucellar, anatropous; fruit an achene or nutlet; embryo straight, the cotyledons grading gradually into the radicle; cotyledons 4 times wider than the radicle, 0.5–0.8 the length of the embryo; endosperm 0.

Composition: 1 genus, 1 species.

Distribution: Eastern and western Australia, with a narrow southern connecting strip.

CALYCERACEAE (Figure 161*c,d*).—Herbs, rarely suffrutescent; xylem vessel perforation plates simple; secretory cavities and external glands absent; phloem strands absent from cortex; leaves alternate, sometimes rosulate, simple, entire or pinnately lobed, exstipulate; inflorescence an involucrate head; flowers bisexual, rarely the central flowers of a head ♂ by abortion, rarely cleistogamous, actinomorphic or zygomorphic; sepals 5 (4–6), the calyx-tube adnate to the ovary; petals 5 (4–6), connate, the lobes valvate in bud; stamens 5 (4–6), the filaments free or connate, inserted high on the corolla; anthers free or connate around the style; pollen 3-colporate; disk absent; pistil 1, the carpels 2, style 1, elongated, not indusiate, the stigma apical, capitate; ovary inferior, unilocular, the ovule 1,

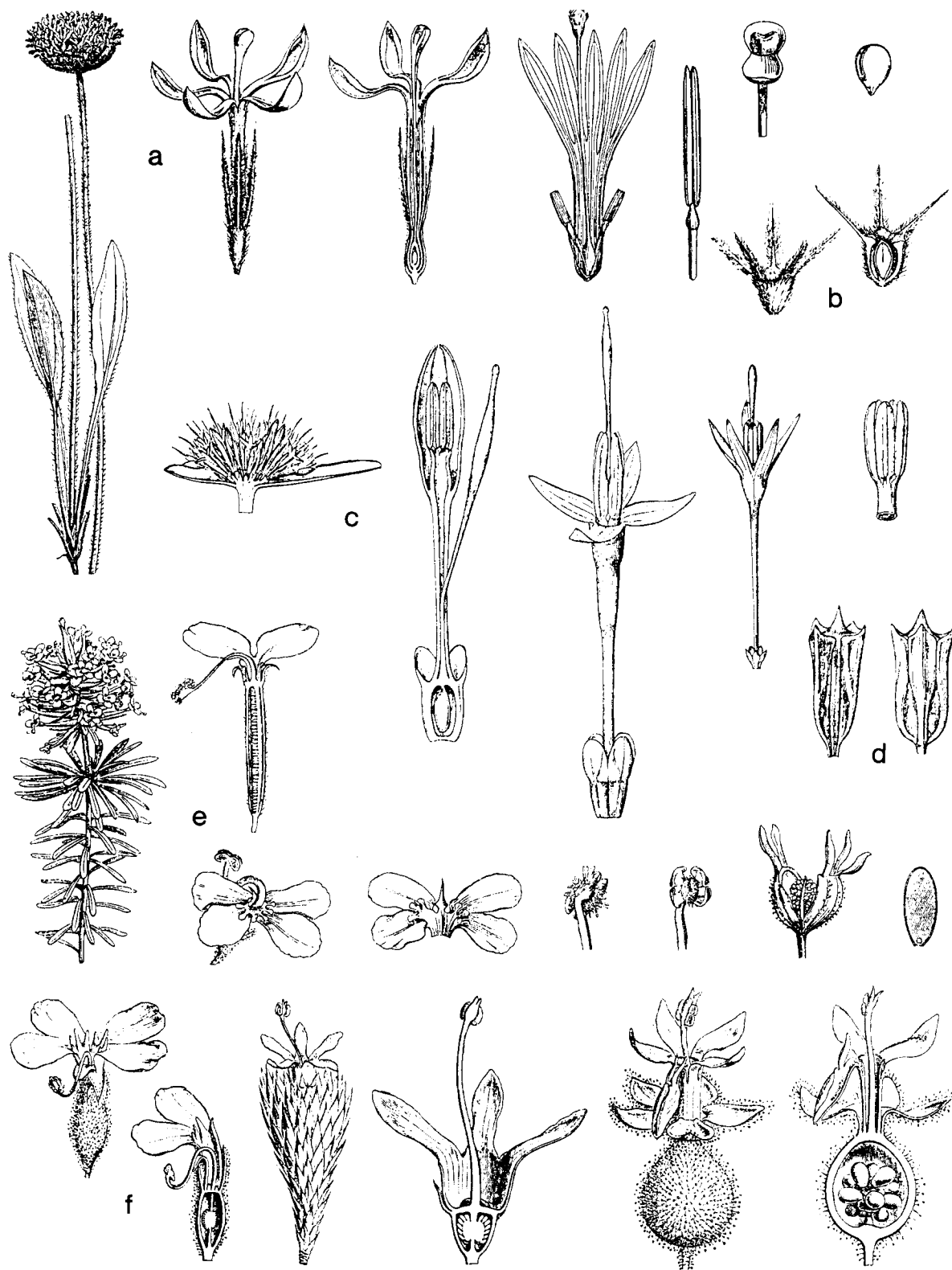
apical, unitegmic, tenuinucellar, anatropous; fruit an achene or nutlet; embryo straight, 0.75–0.9 the length of the endosperm; cotyledons as wide as the radicle, 0.25–0.3 the length of the embryo; endosperm copious or scanty, fleshy.

Composition: 4 genera, 50 species.

Distribution: Southern half of South America, most commonly in the Andes, mainly in dry habitats of scrub and steppe vegetation.

STYLIDIACEAE (Figure 161*e,f*).—Herbs or rarely undershrubs; the sap not milky; xylem vessel perforation plates simple; leaves simple, entire, alternate, sometimes rosulate or in whorls on the stem, exstipulate; inflorescence terminal raceme, spike, corymb, or cymes, sometimes scapose; flowers bisexual or unisexual and then the plants usually monoecious, mostly zygomorphic; sepals 5 (4–9), the calyx-tube adnate to the ovary, or the sepals free or connate; petals 5 (4–9), often with a paracorolla, connate, the lobes imbricate in bud, the lowest one often smaller or larger than the others; stamens 2, the filaments connate and adnate to the style, but not to the corolla; anther sacs sometimes separate; pollen 3–6-colpate, spinuliferous; disk present or absent; pistil 1, the carpels 2, style 1, divided apically, not indusiate; ovary inferior, bilocular or unilocular, the ovules numerous per locule, axile or free-central, unitegmic, tenuinucellar, anatropous; fruit a septicidal capsule or rarely indehiscent; seeds small, the embryo minute, barely differentiated, 0.06 the length of the endosperm; endosperm copious, fleshy and oily.

FIGURE 161.—BRUNONIACEAE: *a*, *Brunonia australis* plant in flower, flower, 1.s. of same, same laid open, stamen, stigma and indusium; *b*, fruit, embryo, 1.s. of same (after Baillon, 1866–1895; Le Maout and Decaisne, 1873). CALYCERACEAE: *c*, *Boöpis bupleuroides* inflorescence, 1.s. of bud, flower, *Acicarpha procumbens* flower, anthers and apex of filament tube; *d*, *Boöpis bupleuroides* views of fruit (after Martius, 1840–1906). STYLIDIACEAE: *e*, *Stylidium adnatum* flowering shoot, 1.s. of flower, flower, corolla laid open, 2 views of androecium and stigma, dehiscent fruit, 1.s. of seed showing the minute embryo; *f*, *S. graminifolium* flower, 1.s. of same, *Phyllacne magellanica* plant in flower, 1.s. of flower, *Levenhookia pusilla* flower, 1.s. of same (after Baillon, 1866–1895; Le Maout and Decaisne, 1873).



Composition: 5 genera, 140 species.

Distribution: Centered in Australia; few species in New Zealand, eastern India, southern parts of the East Indies, and southern tip of South America.

ASTERALES

The order is monotypic.

ASTERACEAE (Figure 162*a-f*).—Mostly herbs, sometimes shrubs, rarely trees or climbers, often with a taproot; xylem vessel perforation plates simple, rarely also a few scalariform or reticulate plates; medullary and cortical bundles sometimes present; intraxylary phloem present in 3 genera; glandular hairs sometimes present; laticiferous vessels present in 2 tribes; oil tubes often present; leaves more often alternate than opposite, rarely whorled, sometimes rosulate, simple, toothed to deeply dissected, more rarely entire, exstipulate; inflorescences terminal racemose heads, sometimes in short dense spikes, involucrate, very rarely individual flowers surrounded by bracts; flowers actinomorphic or zygomorphic, bisexual or the plants monoecious, rarely dioecious; sepals absent or represented by a pappus of scales, bristles or hairs; petals 5 (4), very rarely the ♀ flower apetalous (*Ambrosia*), connate, the lobes valvate in bud, when zygomorphic usually ligulate, rarely bilabiate; stamens 5 (4), inserted on the corolla, the filaments not connate or very rarely connate (*Ambrosia*); anthers basifixed or rarely attached above the base (*Arctotis*, *Gazania*), sometimes tailed or produced apically, connate into a tube surrounding the style, very rarely free; pollen usually 3-colporate, sometimes to 12 apertures, colpoidorate apertures form a transition to pores, sometimes 3–4 (6)-colpate, occasionally rugate, usually spinulose; disk annular, surrounding the base of the style, rarely absent; pistil 1, the carpels 2, style 1, elongated, bifid apically, very rarely 3–5-fid in some flowers of a specimen, stigmas 2 (1), often linear, rarely quite hairy (*Artemisia*), indusium absent; ovary inferior, unilocular, ovule 1, basal, unitegmic, tenuinucellar, anatropous, the embryo sac often with

increased number of antipodal nuclei; fruit an achene (cypsela), very rarely a drupe (*Chrysanthemoides*); embryo straight, the cotyledons usually moderately thick and broad, plano-convex, rarely semicylindrical or convolute, 4 times wider than and grading gradually into the radicle, 0.3–0.8 the length of the embryo; endosperm 0.

Composition: ~900 genera, ~14,000 species.

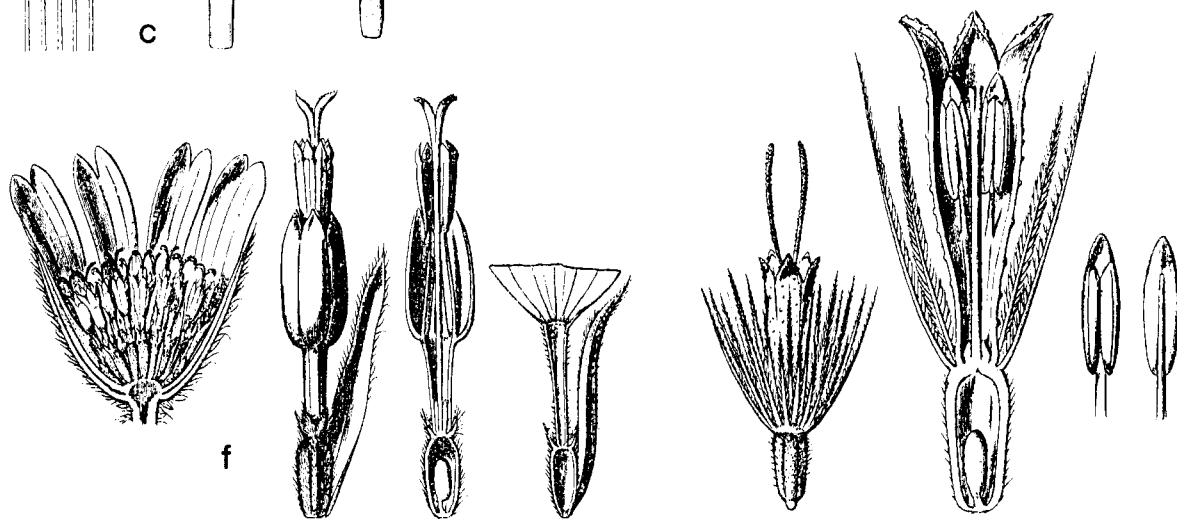
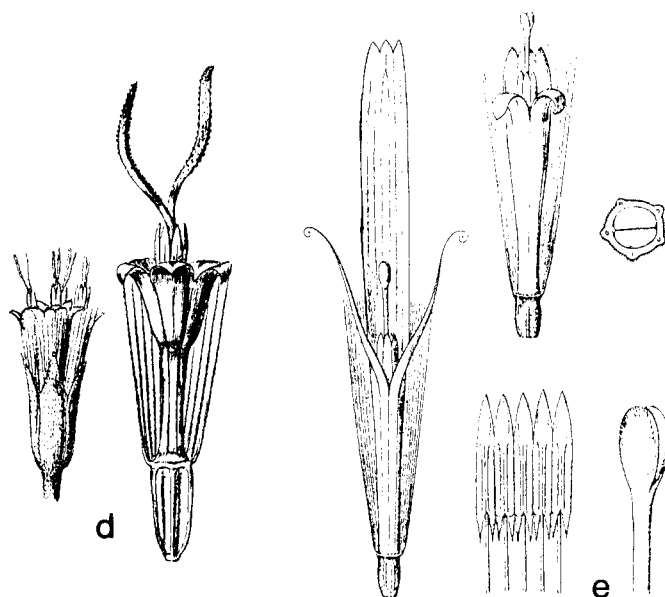
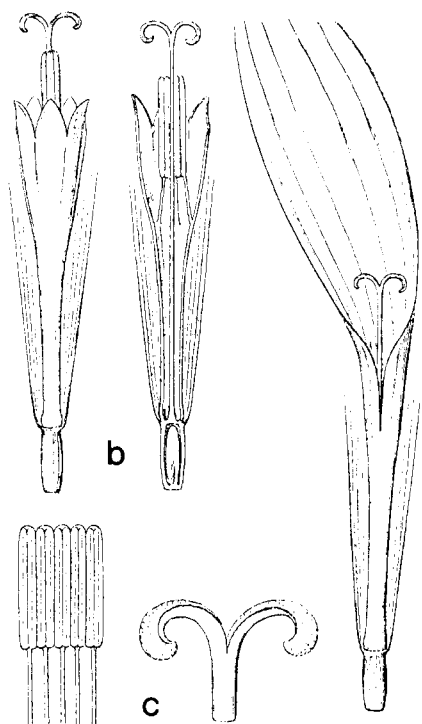
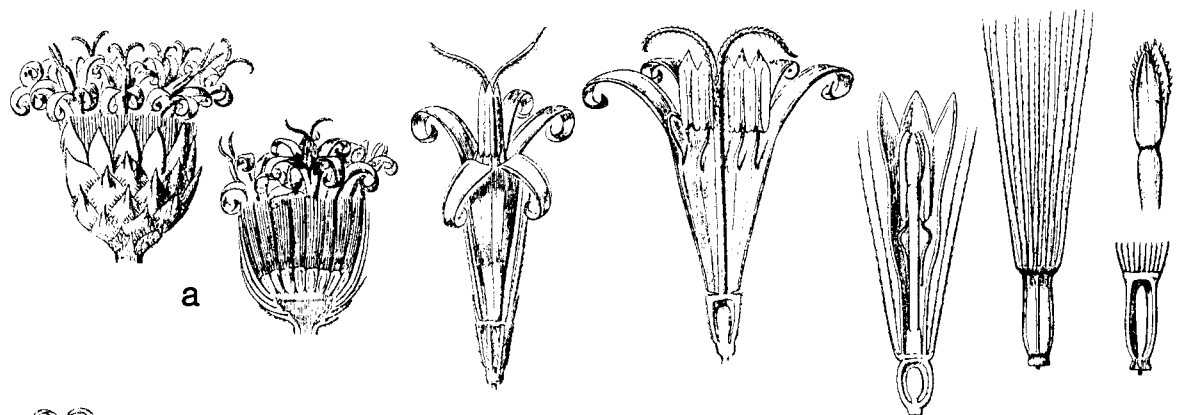
Distribution: Cosmopolitan; best represented in temperate and subtropical regions, in almost all habitats, but especially dry ones; uncommon in wetlands and tropical rain forest; Eupatorieae, Vernonieae, Heliantheae, and Liabeae are centered in the subtropics of America, the second also in Africa and Asia; the Cardueae and Lac-tuceae are centered in the Mediterranean region and Near East, the Anthemideae in those regions and South Africa; the Calenduleae and Arctoteae are centered in South Africa; the Mutiseae are centered in temperate regions of South America, especially the Andes and Guayana Highlands, and in Africa.

INCERTAE SEDIS

I cannot suggest a position for the following families.

TREMANDRACEAE (Figure 163*a-c*).—Xeromorphic shrublets, rarely twining; xylem vessel perforation plates simple, perhaps sometimes also a few scalariform plates present; leaves alternate, opposite, or verticillate, rarely absent, simple, entire or toothed, often glandular, sometimes stellate tomentose, exstipulate; flowers solitary, axillary, long pedicillate, bisex-

FIGURE 162.—ASTERACEAE: *a*, *Vernonia macrophylla* inflorescence, l.s. of same, flower, l.s. of same and corolla laid open, *Erigeron maximus* l.s. of flower, fruit with pappus, stigmas and l.s. of fruit; *b*, *Senecio erisithalifolius* disk flower, l.s. of same; *c*, anther tube laid open, stigmas, base of ray flower; *d*, *Mikania scandens* inflorescence, flower, *Trichocline macrocephala* ray flower, disk flower, c.s. of fruit; *e*, anther tube laid open, stigmas; *f*, *Aspilia setosa* l.s. of inflorescence, *A. foliosa* disk flower, l.s. of same, l.s. of base of ray flower (sterile), *Agrianthus empetrifolius* flower, l.s. of same, views of anther (after Martius, 1840–1906).



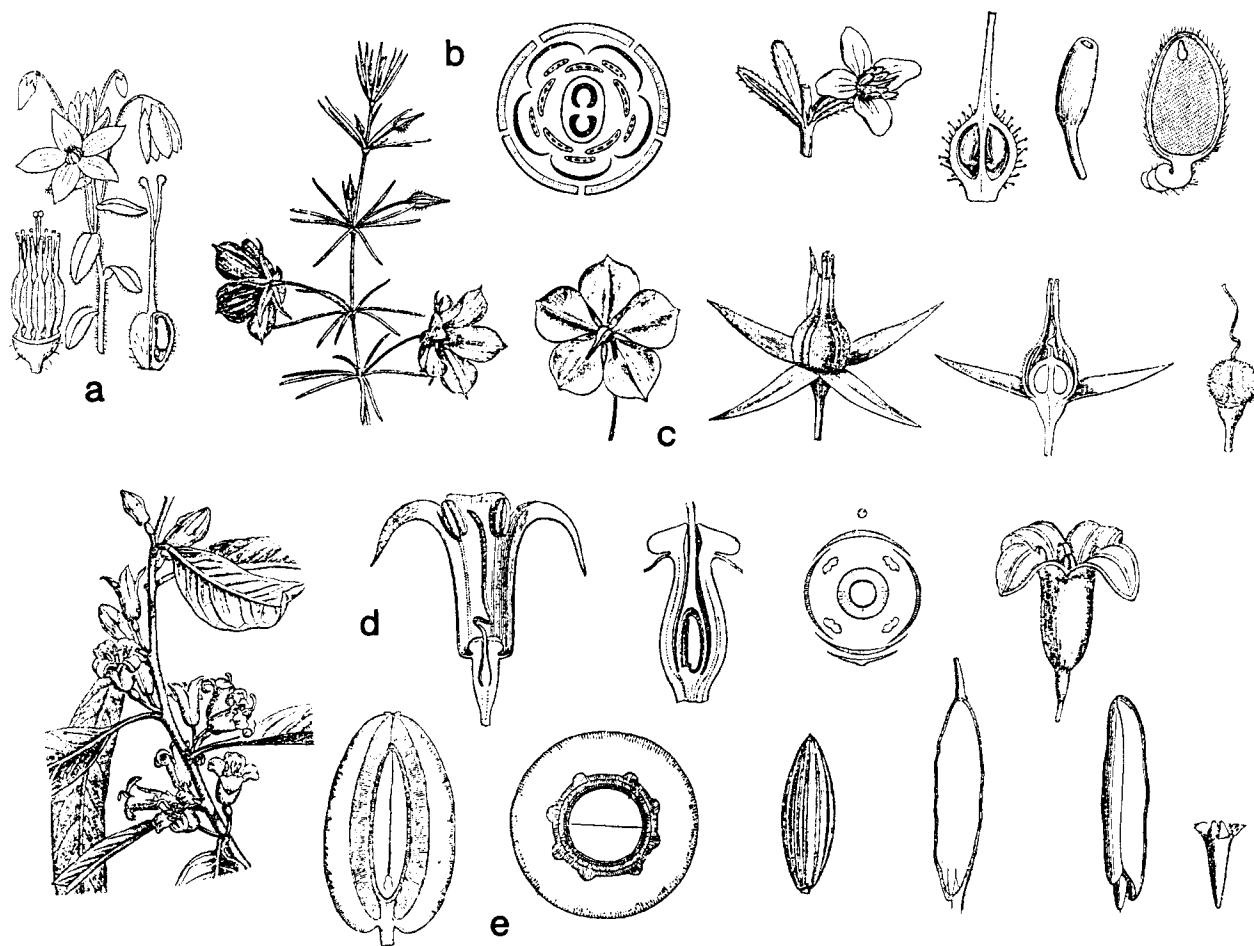


FIGURE 163.—TREMANDRACEAE: *a*, *Tetratheca hirsuta* essential organs, flowering twig, pistil with one of the ovary locules laid open; *b*, *T. verticillata* flowering twig, floral diagram, *T. procumbens* flower, 1.s. of pistil, stamen, 1.s. of seed showing the minute embryo; *c*, *T. verticillata* flower, same with corolla removed, 1.s. of same, pistil (after Lindley, 1853; Le Maout and Decaisne, 1873). ELAEAGNACEAE: *d*, *Elaeagnus angustifolia* part of flowering twig, 1.s. of flower, 1.s. of ovary and part of perianth, floral diagram, ♂ flower; *e*, 1.s. and c.s. of fruit, stone, 1.s. of seed, embryo, radicle and plumule (after Le Maout and Decaisne, 1873).

ual, actinomorphic, the parts hypogynous; sepals 4–5 (3), free, rarely basally connate, valvate in bud; petals 4–5 (3), free, induplicate-valvate; stamens 8, 10 (6), free, in 1 or 2 series, the filaments very short, or elongated; anthers elongated, sometimes beaked, the beak sometimes longer than the locules, dehiscing by a single apical pore; pollen 3-colporate or 3-colporoidate; glandular, annular, lobate disk sometimes present between the petals and stamens;

pistil 1, the carpels 2, (an occasional pistil has 3 carpels), style 1, rarely bifid for 0.3 its length, elongated, slender, the stigma(s) apical punctiform or slightly capitate; ovary bilocular, the ovules 1–2 (–4) per locule, axile, sometimes subapical, bitegmic, crassinucellar, anatropous; fruit a compressed capsule, dehiscence loculicidal and sometimes also septicidal; seeds pilose or glabrous, often with a conspicuous chalazal appendage; embryo straight, cylindrical, 0.7 the length

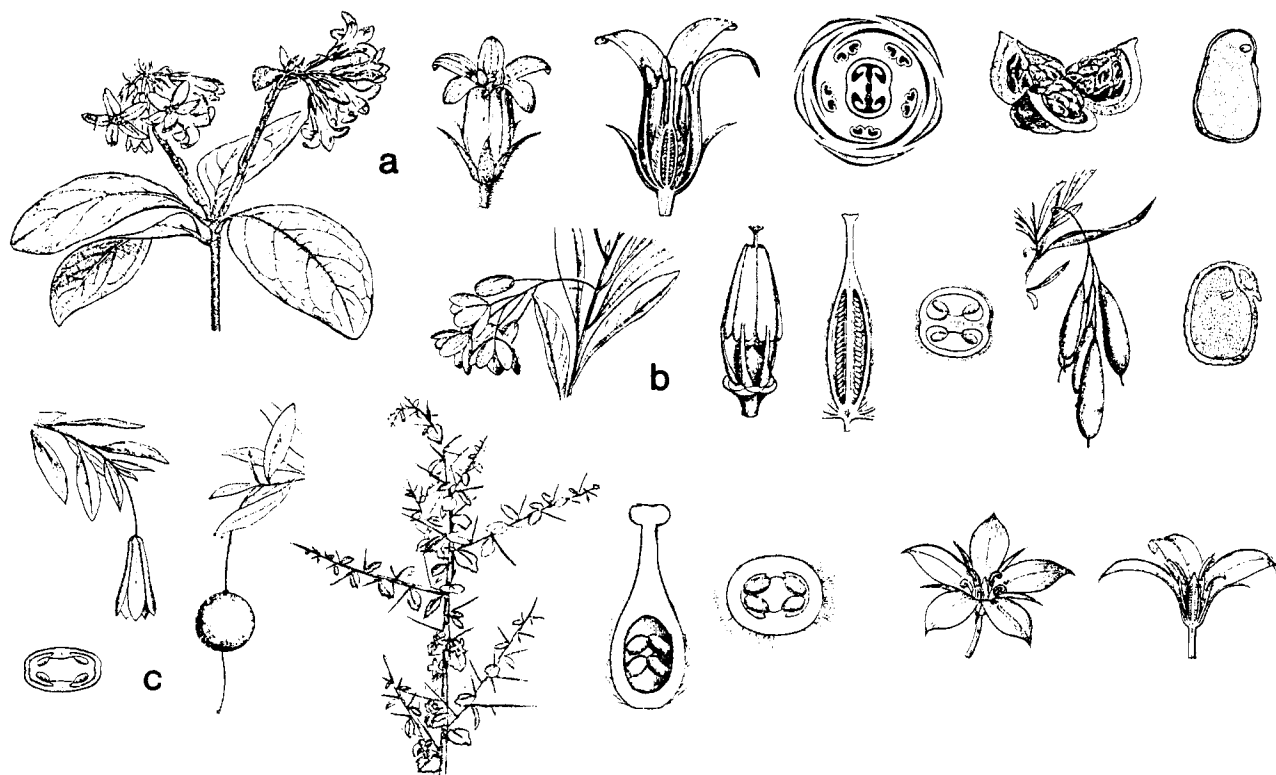


FIGURE 164.—PITTOSPORACEAE: *a*, *Pittosporum revolutum* flowering twig, flower, l.s. of same, floral diagram, *P. tobira* dehiscent fruit, l.s. of seed showing the minute embryo; *b*, *Sollya heterophylla* part of flowering twig, essential organs, l.s. of pistil, c.s. of ovary, infructescence, l.s. of seed; *c*, *Billardiera longiflora* flowering twig, c.s. of ovary, part of fruiting twig, *Citriobatus multiflorus* flowering branch, l.s. of pistil, c. s. of ovary, *Pronaya elegans* flower, l.s. of same (after Baillon, 1866–1895; Pax).

of the endosperm, the cotyledons not broadened, 0.2 the length of the embryo; endosperm copious, fleshy or subcartilaginous.

Composition: 3 genera, 30 species.

Distribution: Extratropical Australia, especially southern Western Australia.

ELAEAGNACEAE (Figure 163*d,e*).—Shrubs and small trees, sometimes the branchlets ending in thorns, sometimes producing gum when traumatized; root nodules containing nitrogen-fixing organisms present; tannins abundant; xylem vessel perforation plates simple; parenchyma diffuse; leaves alternate or rarely opposite, simple, entire, the indument lepidote, rarely also stellate, exstipulate, stomata of ranunculaceous type; inflorescences axillary or at defoliated nodes of

previous year's growth, fascicles, spikes, racemes, corymbs, cymes or the flowers solitary; flowers actinomorphic, bisexual or the plants dioecious or polygamous; sepals 4 (2–8), connate, the calyx tubular or rarely saucer-shaped (*♂ Hippophaë*), the lobes valvate in bud, often colored; petals 0; stamens 4 (3–5), alternisepalous or 8, the filaments inserted at throat of calyx or rarely free, short or elongated (*Hippophaë*), or rarely the anthers sessile; anthers oblong or as long as wide, dorsifixed or subbasifixed (*Hippophaë*); pollen 3 (2)-colporate, or rarely 4-ruporate; disk usually present, inserted at throat of calyx-tube, conic, cup-shaped or of 8 separate glands; pistil 1, unicarpellate, style elongated, the stigma laterally decurrent, linear or rarely subcapitate; ovary

superior, ovule 1, basal, bitegmic, crassinucellar, anatropous; fruit an achene but drupe- or berry-like due to development of the closely investing calyx-tube; embryo large, straight, 0.9 the length of the endosperm, the cotyledons thick, plano-convex, 0.7–0.8 the length of the embryo, 2.0–3.5 times wider than the radicle, the latter partly invested; endosperm scanty or 0.

Composition: 3 genera, 50 species.

Distribution: Mostly coastal regions and steppes in temperate regions and mountains of subtropical regions; temperate North America and temperate to tropical Eurasia, one species extending to northeastern Australia.

PITTOSPORACEAE (Figure 164*a–c*).—Trees, shrubs, and climbers; xylem vessel perforation plates simple, very rarely scalariform with few bars (1–10); resin abundant in canals in the bark; leaves simple, alternate, or whorled, usually entire, very rarely sinuate-toothed, juvenile leaves of *Pittosporum anomalum* are serrate, sometimes pellucid-dotted (*Citriobatus*), exstipulate; inflorescences axillary or terminal, mostly thyrses, rarely simple cymes, corymbose, or the flowers solitary; flowers bisexual, rarely the plants polygamous, actinomorphic, rarely slightly zygomorphic (*Cheiranthra*); sepals 5, free or connate;

petals 5, free or basally connate, imbricate, the claws often connivent; stamens 5, alternipetalous, free, sometimes connivent, hypogynous; anthers lanceolate-oblong, basifixed or subbasally dorsifixed, rarely connivent around the style, dehiscent longitudinally or by 2 apical pores; pollen usually 3-colporate, occasionally 4-ruporate or 4-rupate; disk absent, rarely present at the base of a stipe (*Citriobatus*); pistil 1, the carpels 2 (3–5), style 1, short or long, the stigmas apical, capitate, almost entire or obscurely 2–5-lobed; ovary superior, unilocular, rarely 2–3-locular or incompletely 2–5-locular, the ovules several per locule, parietal or basal, rarely axile, unitegmic, tenuinucellar, anatropous and campylotropous?, the funicles sometimes long (*Bursaria*); fruit a loculicidal and sometimes also septicidal capsule or berry, rarely dry and indehiscent, the seeds 1–numerous, rarely winged; embryo undifferentiated, minute, linear, straight, 0.1 the length of the endosperm; endosperm copious, firm-fleshy.

Composition: 9 genera, 220 species.

Distribution: Centered in Australia, especially southern Western Australia, extending into tropical regions; *Pittosporum* also in tropical and subtropical Africa, Madagascar, Asia, and East Indies, and New Zealand.

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