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Flowering Plants & Ferns

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AND

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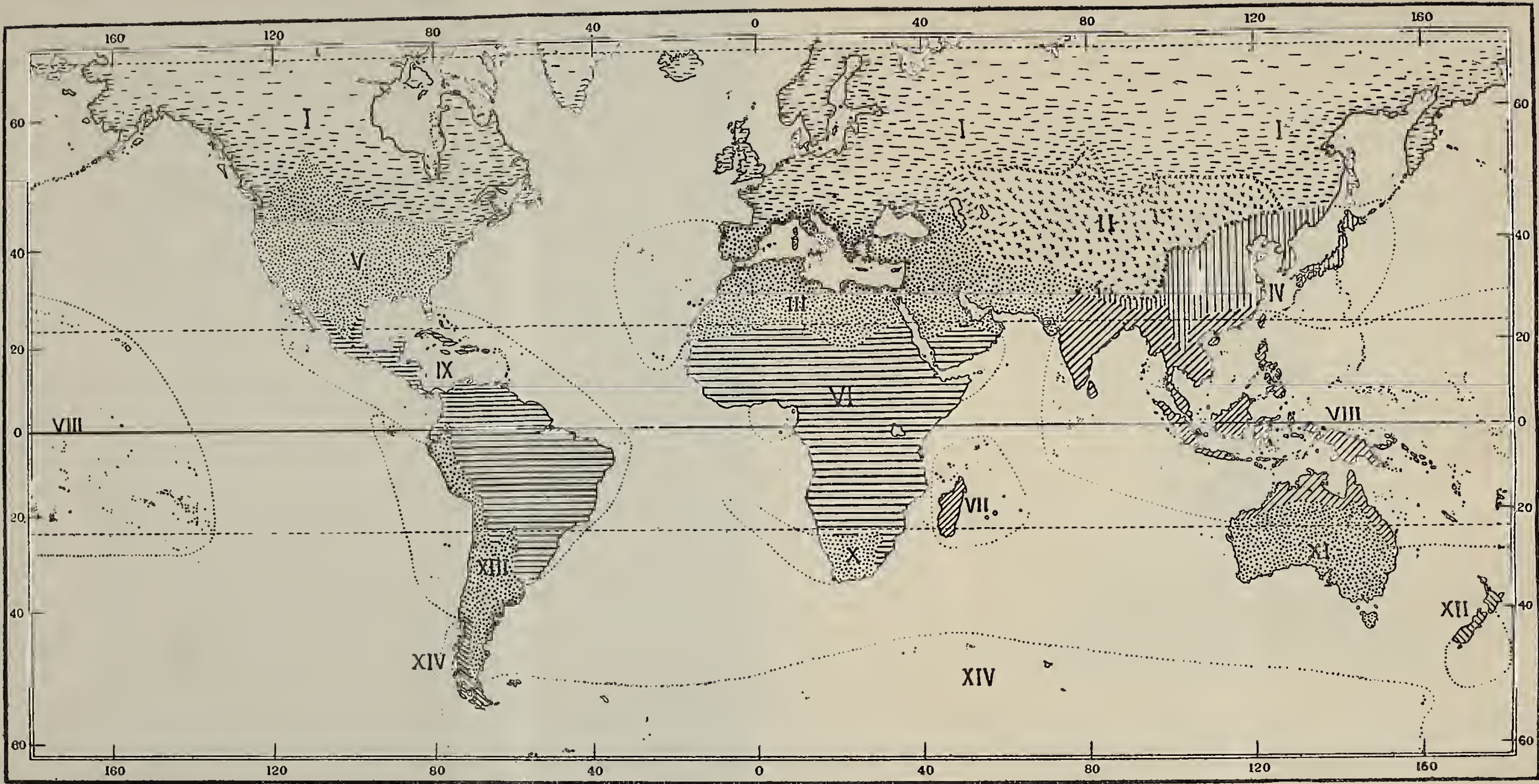

FLORAL REGIONS OF THE WORLD (after Drude).

I. Northern
II. Central Asiatic
III. Mediterranean and Orient
IV. Eastern Asiatic
V. Central North American
VI. Tropical African
VII. East African Island
VIII. Indo-Malayan
IX. Tropical American
X. South African
XI. Australian
XII. New Zealand
XIII. Andine
XIV. Antarctic

A MANUAL AND DICTIONARY

OF THE

FLOWERING PLANTS

AND

FERNS

BY

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SECOND EDITION

revised and rearranged in one volume

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PREFACE.

THE following extracts from the preface to the first edition will serve to indicate the general inception and the scope of the work.

"The aim with which I commenced, nearly seven years ago, to prepare this book, was to supply within a reasonable compass, a summary of useful and scientific information about the plants met with in a botanical garden or museum, or in the field. The student, when placed before the bewildering variety of forms in such a collection as that at Kew, does not know where to begin or what to do....The available works of general reference are mostly very bulky and often out of date, and as a rule refer only to systematic or economic botany, and say nothing about morphology or natural history. I have endeavoured to bring together in this book as much information as is required by any but specialists, upon all plants usually met with, and upon all those points—morphology, classification, natural history, economic botany, &c.—which do not require the use of a microscope.

"The principal part of the book consists of a dictionary in which the whole of the families and the important genera of flowering plants and ferns are dealt with. The families are treated very fully, more so than in any ordinary text-book of systematic botany, whereas the genera are treated much more briefly unless they show some feature of special interest that is not common to the family. This mode of treatment has been adopted for two reasons—to prevent the student from regarding the genera as isolated and unconnected units, and to avoid repetition. To give the generic characters in a work of this kind would...enormously increase the bulk. The treatment adopted involves a good deal of cross-reference, but will impress upon the student the relationships of the members of the vegetable kingdom to one another.

"Finding that Part II was still wanting in co-ordination, I wrote Part I to supplement it....Our existing text-books of morphology are mostly out of date and have little evolutionary basis; the principles of classification and evolution are not explained in the elementary books, and the advanced books take for granted that the reader is familiar with them; no good text-book of the natural history of plants or of their geographical distribution is at present available in English. I have therefore written Part I in such form that it makes in itself a fairly complete treatise upon these subjects; at the same time it is throughout designed for purposes of cross-reference from Part II, and may be itself expanded to almost any extent by reference to Part II for details. The method of treatment adopted is novel, and is based on that which I have employed for several years in my lectures. The morphology of the vegetative organs is dealt with generally in Chapter I, and in more detail in Chapter III in connection with the natural history and geographical distribution;...the morphology of the flower is treated in full in Chapter I, in connection with its natural history and from an evolutionary standpoint. I have adopted this method both because it seems to me to make more clear the meaning of the morphological phenomena and the connection between morphology and other branches of botany, and because I have wished to place before the student some of the general ideas underlying modern research, with a view to suggesting directions in which further research is desirable and likely to be profitable.

"The second portion of this work is of course chiefly a compilation; a few original observations are inserted, but none of any importance. I desire in the first place to express my warmest thanks to Professor A. Engler, for his kind permission to use the materials contained in *Die natürlichen Pflanzenfamilien*, a permission of which I have very largely availed myself, the descriptions of many of the families being almost entirely based upon that work. I am also indebted to him and to Herr Engelmann for the use of the late Professor Eichler's figures. Many other books, and hundreds of original papers have also been used in preparing Part II; the chief of these are mentioned on a later page."

The first edition was in two volumes. This was, I now think, a mistake, for Part I is indispensable for purposes of cross-reference from Part II by all but specialists. In this edition the whole is combined into one volume, while Part I is shortened as much as possible by the omission of controversial matter, and by the use of smaller type for paragraphs of descriptive terms and other articles not intended for consecutive reading.

The former edition has been favourably received among travellers, residents in outlying districts, schoolmasters, and the considerable class of people who have an indirect interest in botany and need some work of general reference in that subject. Bearing in mind their requirements, and those of botanical students, I have improved the present edition by the incorporation of a large mass of new material. Articles on outfit, on collecting and preserving material, on observing and recording, and on general field work, have been added to the introduction. The treatment of morphology, ecology, and geographical distribution in Part I has been made more categorical, and a large quantity of new and important matter has been added. The bulk of the technical terms in common use are now explained in Part I, while a large number of others met with from time to time in floras and similar works have been added to the index (Part III). Part II has been revised, and considerable portions of it rewritten. Great additions have been made to Part III, not only of technical terms and common names, but also of the commoner Latin and Greek prefixes and suffixes used in generic and specific names and technical terms, together with the commoner specific names and their English meanings. The tables of abbreviations have also been incorporated with this part. In these and other ways I have tried to render the work sufficiently complete for the requirements of the readers indicated above, and a reliable work of reference for all interested in botany. With this work and a local flora of the district visited, the traveller or student should be practically independent of other botanical literature for all ordinary purposes. At the same time, for the student at home, the work forms a treatise on general morphology and ecology, geographical distribution, and especially systematic botany, together with a very full dictionary of technical terms and economic botany. Part I is written so that it may be read consecutively by a student who has a slight acquaintance with the rudiments of botanical knowledge; the more difficult paragraphs may be omitted at the first reading and read subsequently.

In preparing the first edition I was indebted for help and advice to many friends, especially Professors Bower, Marshall Ward, and Bayley Balfour, Sir William Thiselton-Dyer, and Messrs Francis Darwin and I. H. Burkill, besides Messrs Lang, Seward, Tansley, Lynch, Church, Moore, Dewar and others. Since it appeared, I have received many valuable suggestions from the above and other friends, notably Drs Augustine Henry and A. J. Chalmers, Professors G. L. Goodale and J. B. Farmer, and Mr R. H. Lock. As with the former edition, so in this, I am indebted to Mr A. E. Shipley for his kind cooperation in many ways.

JOHN C. WILLIS.

ROYAL BOTANIC GARDENS,
PERADENIYA, CEYLON,
November 17*th*, 1903.

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INTRODUCTORY CHAPTER

I. THE SCIENCE OF BOTANY AND ITS SUB-DIVISIONS.

The Vegetable Kingdom is composed of a vast number of plants of different kinds and of various forms, growing in greater or less abundance over most of the surface of the globe, except where prevented by extreme drought, cold, or darkness. The rocks contain great numbers of fossils, representing, in a fragmentary way, some of the plants which have occupied the earth in former ages. These innumerable facts or phenomena, then, are the groundwork or material with which the Science of Botany is concerned; it aims at knowing all about these plants, their life, their structure, their relations to the physical environment and to other forms of life, their functions and uses, their origin, migrations, and distribution, and the laws which govern all these, the past history of the vegetable kingdom from the commencement of life on the earth, and the relationships to one another of all plants, living or extinct.

The earlier students of plants occupied themselves mainly with the detailed study of the external form and structure of plants, a study which has gradually become more and more comparative and now forms the science of *morphology*, and with the investigation of their uses to mankind—the science of *economic botany*. It was soon realised that plants show greater or less degrees of mutual similarity in structure, and that they can be arranged in groups within groups accordingly: attempts at classifying them in a satisfactory manner according to their structural likenesses, or affinities, have continued with gradually increasing success for many years; this line of study constitutes the science of *systematic botany*, *classification*, or *taxonomy*, and is based on comparative morphology. This in turn has itself been aided by the microscopic study of the internal structure of plants—*anatomy*, and minute anatomy or *histology*—especially in the earlier embryonic stages (*embryology*) of the life-history.

Mainly through the work of Charles Darwin, it has in recent times been admitted that an *evolution* of the vegetable kingdom from a few simple to many complex forms has occurred and is still proceeding, and that structural affinity is really an expression of relationship by descent. A complete revolution has thus taken place in the science. Taxonomic study now aims not merely at classification of now living forms, but also at tracing out their past descent from other forms, or *phylogeny*. Hence too, the study of *fossil botany*, or *palæobotany*, has of recent years become of great importance.

Morphology has participated in the change of view, though only within the last few years. It is now clearly recognised that it too must be comparative, and based upon phylogeny, and that the classification of the organs or parts of plants is often almost as difficult as that of the plants themselves and involves the same phylogenetic considerations. At the same time it is recognised that the structure of an organ is intimately related with its function, and that change in the latter usually involves change in the former, and vice versa. Hence the modern morphology is studied largely in connection with *physiology*—the investigation of the functions of plants and their constituent parts or organs. Closely connected with physiology is *ecology* or *natural history*, the study of the functional, competitive, and other relationships of plants to their physical environment and to one another, and this throws very great light upon the meanings of the morphological features of plants.

A very important proximate cause or mechanism of evolution is the *variation* which is so marked a feature of all plants and parts of plants; the study of this is now coming into great prominence, as there are two rival theories in the field as to the mechanism of evolution, based chiefly on the two forms of variation which appear to characterise living organisms.

Plants are not distributed at haphazard upon the surface of the earth; each kind occupies a definite area. The study of the facts thus supplied by exploration and taxonomy forms the science of *geographical distribution.* The explanation of the facts involves the study of physiological, physical, and ecological conditions in all parts of the world, the past geological history of the earth, the morphology and phylogeny of the plants, their method of migration, their variation, &c., and at the same time helps to throw light upon all these subjects.

It is also becoming recognised that, since geological evidence indicates that existing plants are descended from plants of warm climates, it is very important that a close study should be made of the existing tropical flora, and especially from an ecological and physiological point of view and in connection with fossil botany and morphology. Our present generalisations are too largely based on the phenomena of plants in cold countries, where the species are fewer and where the effect of climate is so strongly marked that it masks the individual peculiarities of plants. Many of these generalisations are only special cases of wider ones to be drawn from the study of *tropical botany.*

Other important lines of work are also arising from the subdivision of those mentioned, *e.g.* the study of the diseases of plants, or *vegetable pathology*, which is an offshoot of physiology and ecology.

All branches of Botany, then, are mutually interdependent, and also require the aid of physics, chemistry, zoology, geology and other allied sciences. They must be studied so as to throw light upon one another's problems, not as if they were independent sciences. It is from this point of view that the following pages are written.

II. SUGGESTIONS TO STUDENTS AS TO THE METHOD OF USING THIS BOOK.

THE present work is not intended as a mere dictionary of miscellaneous information about plants, but also and in an equal degree as a guide to the scientific study of morphology, natural history, geographical distribution, classification, economic botany &c. A few suggestions, therefore, as to the mode of using the book may not be out of place.

While in Part II. no particular effort has been made to avoid technical language, the terms and expressions employed are so far explained in Part I. that it is hoped that the book will be found available by any one, though it is recommended that a preliminary study be made of any of the small elementary treatises on Botany, *e.g.* F. Darwin's *Elements of Botany* in this series of Manuals. An explanatory index will be found at the end of the book.

The student will do well to confine his attention during the first summer and autumn to the elements of morphology and natural history; these are dealt with in Chapter I.; specimens should be obtained, dissected, and described in technical language, and careful sketches made of points of interest; too great stress cannot be laid upon the importance of careful description and drawing, which enforce attention to essential and important features. The sections in Chapter III. dealing with Herbs, Shrubs, and Trees should also be read. During the winter he should study carefully the various ways in which plants hibernate and store up reserves for the growth of the next spring; this will naturally lead to a thorough study of the morphology of buds, and of tubers, rhizomes and other underground parts.

As soon as a few flowers begin to appear out-of-doors, the study of classification may be begun. At first no attempt should be made to learn the characters of the natural orders, nor to study the principles of classification, but a thorough study should be made, with the aid of both parts of this book, of all obtainable plants belonging to about a dozen or twenty of the large orders, chosen as representatives of the various sections of the natural system, *e.g.* the following:

Compositae, Rubiaceae; Labiatae, Primulaceae or Myrsinaceae, Ericaceae; Umbelliferae, Malvaceae, Leguminosae, Rosaceae, Cruciferae, Ranunculaceae, Caryophyllaceae, Betulaceae or Piperaceae; Orchidaceae, Liliaceae, Gramineae; Coniferae; Selaginellaceae; Polypodiaceae.

After a considerable number of plants and flowers of these orders has been examined, dissected, described, and sketched, the student will be able to refer to its relationships any unknown plant of these orders that may be given to him. He will now have a practical acquaintance with the class of facts with which systematic botany deals, and should study the principles of the subject (see Chapter II.) and the different systems of classification in use. He should not however be content with merely finding out the order to which an unknown plant belongs, but should further study the sub-division of these orders into their tribes; this will help him in grasping the principles of classification. Lastly, with the aid of Hooker's *British Flora* or the similar work referring to his own district he should endeavour to identify the genus and species of all wild plants which he recognises as belonging to the orders he has studied. While he studies the classificatory details of flowers &c., he should of course pay attention to interesting features in their morphology or natural history, and Part II. will aid him in this. The various subjects treated in Chapter III. should also be worked at one by one and studied in a botanic garden, in museums, and in the field, with the aid of the details given in Part II., and with reference to original papers for further information. A third season may be employed in a similar way by increasing the number of natural orders studied; the new ones will group themselves in the mind round those already familiar. It is best not to attempt to add too many new ones at once to the old; about 40—50[1]

[1] These should at any rate include the following orders: Campanulaceae, Cucurbitaceae, Acanthaceae, Scrophulariaceae, Solanaceae, Boraginaceae, Asclepiadaceae, Apocynaceae, Myrtaceae, Melastomaceae, Cactaceae, Sapindaceae, Anacardiaceae, Euphorbiaceae, Rutaceae, Podostemaceae, Saxifragaceae, Papaveraceae, Nymphaeaceae, Chenopodiaceae, Polygonaceae, Proteaceae, Moraceae, Fagaceae, Salicaceae, Casuarinaceae; Zingiberaceae, Iridaceae, Amaryllidaceae, Bromeliaceae, Araceae, Palmae, Cyperaceae, Potamogetonaceae; Gnetaceae, Cycadaceae; Isoetaceae, Lycopodiaceae, Equisetaceae, Salviniaceae,

is the most that should be attempted during a season. The subjects of Chapter III. may now be further dealt with and a commencement made upon Geographical Distribution or upon the details of Economic Botany. A definite piece of field work on the lines suggested in § V. below should also be taken up at this stage.

III. BOTANIC GARDENS.

Most students have access to a Botanic Garden, and should make a special point of visiting it regularly, and working over definite groups of plants with the aid of this book, but it is a great mistake to confine attention to the named and labelled plants of a garden, and every opportunity should be taken of doing real field work (cf. § V.). The notes which follow are intended as suggestions for the use of a botanic garden to good advantage.

The majority of such gardens in temperate climates are arranged on similar lines; they usually contain a *Range of Houses*, representing tropical and warm temperate climates, an *Arboretum* containing native trees and shrubs and others from similar climates, a *Herbaceous Ground* for herbs and small shrubs capable of outdoor cultivation, a *Pond* or *Tanks* for water plants, often fed by a running stream in which or on whose banks other plants may be grown, a *Rock-garden* for alpine plants, succulents, and others that love dry situations or stony soil, a *Bog-garden* for marsh and bog plants, and so on. There are special beds set apart in many gardens for *Agricultural* and *Medicinal* plants &c.

While in the outdoor beds the plants are usually always arranged in the same places, this is not the case indoors. In summer most of the specimens from the cooler houses are carried out of doors and others from hot houses moved into cool. In the houses themselves, with few exceptions,

Ophioglossaceae, Cyatheaceae, Hymenophyllaceae. The further orders studied will depend upon the object the student has in view, whether a general knowledge of botany, or a special knowledge of a particular flora, or of economic botany, &c. The treatment given to the orders in Part II. and the number of their genera and species will give a fair index to their importance.

there is little attempt at any classification of the plants, whether morphological or according to country of origin; they are put in the house best suited to their growth. Certain general principles only can be given to guide a student, and after a little practice, he will know fairly well where to look for a particular plant he desires to see. He will not, for instance, look for East Indian species on the Herbaceous Ground, or for Crassulaceae in the Bog-garden. He will know that few Australian plants, even from the south, are hardy in Britain and will seek them in the Temperate House, and so on.

The Range. Plant houses may be roughly classified into *general* and *special*, and these again into *tropical* and *temperate*. The general houses, such as the Stove or the Temperate House, contain plants of every kind to which the climate of the particular house is suited. The special houses contain representatives of special groups of plants with certain features in common; such as the Succulent House, Tropical Orchid House, Water-lily House.

The list of houses at Kew, which has one of the most extensive and specialised ranges, is as follows: (Tropical) Palm House, Tropical Economics, Aroids, Begonias, Stove, Nepenthes, Water-lilies, Victoria regia, Tropical Ferns, Tropical Orchids, Succulents; (Temperate) Temperate House, Temperate Economics, South African, Conservatory, Temperate Ferns, Filmy Ferns, Temperate Orchids, Alpines, Insectivorous Plants.

In the *Palm House*, *Aroid House*, and *Stove* will be found tropical plants, chiefly from climates where there is plenty of moisture, at least during a large part of the year. Here are most of the Cycads, Palms, Araceae, Bromeliaceae, Musaceae, Zingiberaceae, Marantaceae, Piperaceae, Moraceae, tropical Lauraceae, Leguminosae and Euphorbiaceae, Melastomaceae, Araliaceae, Sapotaceae, tropical Asclepiadaceae, Gesneraceae, Acanthaceae, tropical Rubiaceae and many smaller tropical orders. The contents of *Aroid*, *Begonia*, *Tropical Fern* and *Orchid Houses* are sufficiently indicated by their names. The *Water-lily House* contains various Nymphaeaceae, Hydrocharitaceae, and other tropical and sub-tropical water plants. In most gardens it is festooned with climbing plants, such as Vitis, Cucurbitaceae, Passifloraceae, &c. The *Cactus* and *Succulent Houses* contain xerophytes, chiefly succulent forms from very dry climates, including Cactaceae, Euphorbiaceae, Asclepiadaceae, &c. with fleshy stems, and various Liliaceae, Amaryllidaceae, Aizoaceae, Crassulaceae, Compositae, &c. with fleshy leaves (see Chapter III.). In these houses the air is kept much drier than in the preceding ones.

Among the cooler houses, the *Temperate House* corresponds to the Palm House; here will be found most Australian and other S. Temperate plants, the plants of the Mediterranean and warmer temperate zones, and the plants of the middle zones of the Himalaya and other tropical mountains. Most of the Proteaceae, Rutaceae, Thymelaeaceae, Myrtaceae, Acacias, &c. are to be seen here. The *Heath House* or *South African House* contains Ericaceae, Epacridaceae, &c. from the S. Temperate zone. The *Conservatory* is usually a show house, the plants in which are perpetually changed to keep up a display of flowers all the year round. The names of the other cool houses explain themselves.

The Arboretum contains specimens of trees and shrubs, most of which belong to the orders Coniferae, Juglandaceae, Salicaceae, Betulaceae, Fagaceae, Ulmaceae, Magnoliaceae, Saxifragaceae, Hamamelidaceae, Platanaceae, Rosaceae, Leguminosae, Buxaceae, Aceraceae, Hippocastanaceae, Sapindaceae, Rhamnaceae, Vitaceae, Tiliaceae, Cornaceae, Ericaceae, Oleaceae, Caprifoliaceae.

The Pond, Tanks, and **Bog-garden** contain the hardy water and bog plants, especially those of the native flora. See Chapter III.

The Rock Garden contains most of the hardy alpine and rock plants. Many alpines refuse to grow out-of-doors at low levels, on account of the dampness of the winter, and must be cultivated under glass in the *Alpine House* for a portion of the year. See Chapter III.

The Herbaceous Ground contains the smaller plants suited to ordinary out-of-door culture other than those requiring specially dry or wet situations. Here will be found representatives of most native plants, and foreign plants belonging to the same orders, and also many Commelinaceae, Nyctaginaceae, Phytolaccaceae, Aizoaceae, Capparidaceae, Zygophyllaceae, Rutaceae, Loasaceae, Asclepiadaceae, Polemoniaceae, Hydrophyllaceae, Acanthaceae, &c. Each order has usually a bed to itself, and the beds are grouped according to some system of classification (that of Bentham and Hooker in several gardens).

Visitors are not allowed to pick or handle specimens in botanic gardens, but in most of them specimens may be obtained for purposes of study by application to the Curator or sometimes to the Professor of Botany. At Kew there is a small Students' Garden, where specimens may be picked.

IV. BOTANICAL MUSEUMS.

These are usually designed to illustrate Systematic or Economic Botany, or both; in the former case, and often also in the latter, they are arranged according to the natural families of plants, but some of the best economic museums are arranged by products, usually on a system like that in Chapter IV. Many museums exhibit series of specimens illustrating types of vegetation, morphology of organs, floras of particular countries, &c.

The student will find this book useful in the museum; he should use the collections in connection with his general study and outdoor work, following up the various heads of work in Part I., tracing out illustrative specimens, and should also study natural orders with the aid of Part II., in which also details of every specimen studied should be looked out.

Most good museums also publish guide-books which will supplement the information here given.

V. GENERAL FIELD WORK.

The student should begin field work on the wild flora as soon as he has a good general acquaintance with the elements of morphology and with plants of a few natural orders (cf. § II. above). He will require a "Flora" which will enable him to identify the local plants, in addition to the present work.

While at first it is probably best only to dissect, describe, and identify the plants met with, as suggested in § II., the student, as soon as he feels at home with his work, should undertake a definite piece of field work which will involve the study of the plants in the light of all the various branches of botanical science. He should begin with a definite area, as uniform as he can find, *e.g.* a piece of moor, a sea-shore, a sand-dune, a crag-face, a pond, a roadside bank, an old building, the tops of a group of pollard willows, an oak, pine, beech or mixed wood with its undergrowth, a field or a town-garden with its weeds, a circumscribed plot upon a grass-lawn, &c. This he should study at all times of year, and answer in detail, in writing and with sketches, the following among other questions.

What kind of soil, water-supply, drainage, elevation, exposure to light, exposure to wind, shelter from particular winds, and other physical features has the area in question? How do all these differ from those of the surrounding areas? What species of plants occur? What proportion do they bear to the neighbouring flora? How many other species are there within a short distance? Why are certain species present on the area, and the others of the neighbourhood absent from it? What is the means of dispersal (by seed and vegetatively) of each species in both sets? Is absence of a good means of dispersal enough to account for the absence, and presence of a good means for the presence, of the various species? Has dryness or wetness, the kind of soil or any other physical agent, anything to do with presence or absence of species (test by experiments in planting, and by comparison with areas differing in one of these characters)? What are the relative numbers of each species in a given small portion of the area, *e.g.* in 4 square yards? Do the proportions differ on different small portions, and if so, why? Why are some species much more (less) numerous than others? Is this abundance (rarity) general in the neighbourhood, or confined to the area considered? What special advantages or disadvantages in the general competition has each species, under each of the following and other headings? What are the pollination-methods of the flowers, and how perfect are they? Do they lead mainly to cross- or to self-pollination? What insects visit the flowers, and of what kinds; and what proportion of the total insect-visits of each kind does each flower get? How much seed does each species produce, both actually and in proportion to the possible quantity indicated by its flowers, and to that produced by other species? What are the germination phenomena, and does the species gain any advantage in early, late, or rapid germination? Do any plants gain by early or late flowering, by special arrangements for bud-protection, for wintering, for storage of reserves, by annual or perennial habit, by xerophytic, aquatic, climbing, parasitic, saprophytic, or other peculiarities? What is the exact life-history of each species? and so on.

Other areas, differing from the first, should be examined in the same way, and compared with it, and an attempt should be made to map the whole district into regions characterised by definite vegetations; of course these will shade into one another at their edges. The student will soon find this kind of work fascinating, and it will tax his knowledge of every branch of Botany and suggest innumerable problems for solution, besides supplying abundant material for morphological, anatomical, or embryological study. There is also ample opening for new research in this direction, even in well-known floras like that of Britain, when he becomes proficient.

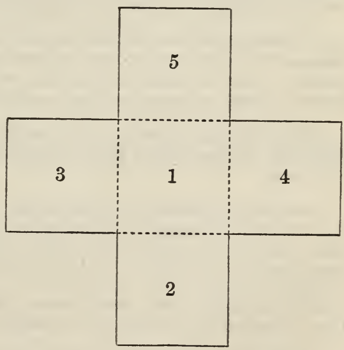
VI. NOTES FOR FIELD BOTANISTS, TRAVELLERS, AND COLLECTORS.

Outfit. Any or all of the following may be needed, according to the places to be visited, and the kind of work to be done. All that is needed should be taken from the start, as it is usually difficult to get suitable things quickly elsewhere; extra supplies of paper, etc. may be sent to the "Poste restante" at places to be visited en route.

Portfolios for pressing plants as collected, lightly made of two strong cloth-covered pasteboards (17 in. × 11 in.) with encircling straps and handle, and to contain 30—50 sheets of paper. Specimens as collected are put at once into these and time is thus saved in making large collections, *e.g.* on a journey in new country.

Collecting tins or vasculums of various sizes for bringing plants home for further study. When slung on the back, the hinges should be on the lower side of the lid, and the bolt should slide downwards to fasten, otherwise it is liable to work loose. Small specimens are best carried in *small round-cornered tobacco or tooth-powder tins*, not among large ones in a general vasculum.

Presses for drying plants; each consists of two outer frames of ¼ inch hoop-iron 17½ × 11½ inches, filled in with stout wire netting soldered to the iron. The papers lie between these frames and the whole is strapped with two stout straps to obtain the pressure.



Lattices, 17 × 11 inches, for admitting air between the masses of plants in the press, made of two sets of parallel thin laths fastened together at right angles.

Drying paper in sheets 17 × 11 inches in ample quantity; stout Manila is best, blotting paper is too fragile. *Mounting paper* in sheets 16½ × 10½ inches (standard size of Kew herbarium) or sheets of newspaper or other common paper for preservation of dry specimens removed from the press. Unfolded *envelopes* of thin paper cut into the shape shown, for seeds, flowers, &c.; place the specimen on 1 and fold over the wings 2, 3, 4, 5 in order. 2 must be the same size as 1.

Waxcloth for tying up bundles of dried and mounted specimens; *waterproof canvas* for covers for presses &c. in case of rain.

Corrosive sublimate (mercuric chloride) and *alcohol* for poisoning specimens; made up as required in the proportion of 1 part to 50. Large *dish* for poisoning. *Naphthalin* for keeping away insects.

Kerosine tins or other square tins with large lids for preserving specimens in alcohol (lids that push in airtight, as in many tobacco tins, are the best); *soldering apparatus* for fastening up when full.

Bottles with stoppers for preserving delicate specimens; neckless *glass tubes*, with corks, of various sizes. Bottles are easily packed in joints of bamboo, tubes in small tins.

Muslin for wrapping alcohol specimens. Each should be wrapped with its label (in Indian ink, or better on metal) in a piece of muslin and packed in the tin; specimens cannot then become mixed together, and can be closely packed.

Alcohol for preserving; ordinary methylated spirit is best for most things, but some require 70 %, alcohol, and some absolute alcohol.

Formalin, *picric acid*, *chromic acid*, *glycerin*, or other preservatives for special work.

Butterfly-net, *killing-bottle*, *insect boxes*, *entomological pins*, if ecological work is to be done.

Hunting-knife, cutlass, or kukri for lopping creepers &c.; *pruning shears* for cutting branches; strong *pocket knives;* strong narrow-bladed *trowels; geological hammer;* strong *rope* for climbing &c.

Travelling microscope and *lenses; dissecting microscope; pocket lenses;* microscope *slides; cover-slips* in alcohol or oil; *scalpels;* dissecting *needles; scissors* large and small and with fine points; *razors* for section-cutting; *forceps; dishes; watch-glasses; camel-hair brushes.*

Reagents and *mountants* for simple microscopic work, *e.g.* iodine, glycerine, haematoxylin, gold-size, canada balsam in xylol, alcohol, oil of cloves.

Compass (prismatic by preference); *spirit-level; aneroid barometer; thermometers* (ordinary, maximum and minimum, wet and dry bulb); *field glass* (very useful for studying cliffs, ravines, trees, &c.); *maps* (geographical, geological, outlines for marking distribution, &c.).

Photographic camera and *lenses; tripod; films* or *plates* in soldered tins; *chemicals* and *dishes* for developing, fixing, &c.

Drawing pencils (hard, medium, soft); drawing *cards; sketch-block; colours; brushes; india-rubber; ink; compasses; ruler; scales* in inches and centimetres; *gum* and *brush; pins.*

Spirit-lamp; tape-measure; string, twine and *thread; thin wire;* sheet-*lead* or *zinc* for labels (if latter, also solution of platinic chloride for writing on it); *glue-pot* and *glue* for mounting.

Note-books with numbered detachable pages, so that the description of each specimen can be separated afterwards; consecutively numbered and perforated *labels* for specimens, the numbers to correspond to those in note-book. The labels may be joined to the pages of the note-book or in sheets like postage stamps. More than one label of each number will usually be needed.

Collecting and Preserving. The following hints will be found useful.

Decide the general object of the work in advance, and collect principally for the furtherance of that object.

In collecting for subsequent distribution, collect enough specimens to go round easily, but do not in any case exterminate or seriously diminish any plant in its native locality.

Do not collect immediately on arrival; first become familiar with the plants and their local features and distribution. Better results are obtained by choosing certain localities as headquarters and working these thoroughly, than by rushing through a large district and changing headquarters frequently.

Do not collect herbarium material in wet weather.

Collect specimens which are as typical as possible, but also take some illustrating the range of variation, the difference of habit and size on different soils or situations, &c.

Collect entire plants where possible, including roots. In case of shrubs or trees, collect twigs with leaves in all stages, portions of stem-bark and anything else necessary to furnish a complete description. Do not forget radical leaves, buds, flowers, ripe and unripe fruits, seeds.

If a large collection is being made, it is quicker to use the portfolio than the vasculum, and to press each specimen as soon as obtained.

Large flowers or heads (*e.g.* thistles), fruits, roots, tubers, &c. may be sliced in half before pressing, or the surface only sliced off. Notes and sketches should be made of the original appearance.

Leaves of Conifers, Heaths, small Succulents, &c. fall off when dried, unless previously immersed for a few seconds in boiling water.

Thorny and prickly plants should first be placed between boards and pressed down with the feet to crush the prickles, which would otherwise tear the papers.

Delicate water plants should be arranged upon sheets of white paper under water, and always remain on these sheets while drying.

It saves time in drying delicate specimens to keep each always in a folded sheet of very thin paper.

Place extra flowers, small fragments, seeds, etc., in small envelopes, numbered to correspond with the specimens; do not have any small parts loose, or confusion may result.

Place all specimens to be dried in the press the day they are collected. Withered plants may be soaked in water; if the stem be cut about 2—3 inches above the former cut and *under* water it will often revive quickly.

Label every specimen with its consecutive number in such a way that the number cannot be lost. Punched labels are best, tied on with thread. See that all envelopes &c. have the same number.

Spread out the specimens as naturally as possible. If many leaves etc. overlap, place bits of drying paper between them. If stems have to be cut, mark the corresponding ends by stars on the paper. Spread out some flowers, leave others unspread, and divide some in the antero-posterior plane. Divide some fruits lengthwise and crosswise.

Arrange the specimens on the sheets so that they form a steady pile without lumps in the middle. Place a lattice upon every five inches of specimens. When all are ready place in the press and draw the straps as tight as possible, or better, place about 60 lbs. weight upon it. Tighten the straps as the plants shrink.

Change the drying papers at least once daily: dry the used paper in the sun or by the fire, and use warm driers where possible. See that petals &c. do not stick to the paper: if necessary put slips of tissue paper under them.

In changing the papers, put the outer specimens inside, so that all shall dry evenly. Drying should be as rapid as possible to prevent loss of colour, blackening, &c.

Fully dried plants no longer feel cold on the cheek, and are stiff and brittle.

Dried specimens should be poisoned by a brief immersion in 2 % solution of mercuric chloride in alcohol. They should then be dried in the air, mounted (with glue) or laid between sheets of paper, and tied up in wax-cloth with a little naphthalin to keep out insects.

Material for subsequent microscopic examination or for museums must usually be preserved in alcohol. Cut into small portions, attach label (best of zinc written on with solution of platinic chloride, but paper and pencil or Indian ink will do temporarily); place in methylated spirit for a few days, wrapped in muslin, and finally preserve in large tin. A few inches of spirit at the bottom, enough to keep all specimens moist when the tin is soldered, will suffice for most material. Specimens for embryological, delicate histological, cytological, and other investigations, and delicate plants or organs, must be separately preserved from the first in absolute alcohol in bottles or tubes. Labels should be put inside these. Contents of bottles may be written on the ground surface of the stoppers, so as to be legible through the neck.

Museum material may also be preserved in formalin (1 part of ordinary solution to 10 or more of water). Some special preservatives, *e.g.* picric and chromic acids, are used in special cases.

Specimens illustrative of economic uses of plants and their products should be collected in less known districts, *e.g.* samples of gums, resins, caoutchoucs, oils, fibres, timbers (portions of trunks, or slabs $8 \times 4 \times 4$ inches), food-products, drugs, dyes, tans, &c. In all cases the exact origin of the product should be verified, and herbarium specimens taken, bearing numbers to correspond with those placed on the products.

From less known countries, endeavour to bring back living seeds (ripe, well dried, packed in charcoal in tins if to be long kept), bulbs (gathered when dry and with withered leaves), succulent plants (gathered dry and loosely packed), living plants (planted in earth in Wardian cases or sometimes in bamboo pots, if possible some weeks before moving).

Recording. The following hints are worth noting.

Make all notes immediately upon observation of the facts; never trust to memory, nor delay recording.

Make all notes about individual specimens upon detachable sheets, numbered to correspond with the specimens; never describe two or more on the same sheet; never use the same number twice.

Make no record till satisfied of the truth and accuracy of the observation.

Accompany all notes with maps, drawings, sketches, or photographs so far as possible.

Sketch and photograph all peculiarities of habit, characteristic forms of vegetation, and other features of interest. Mark all plants in such pictures with numbers corresponding to their numbers in your collection, and write a full description of each picture before leaving the spot. If a photograph is taken, make a rough sketch (from the picture on the focussing screen or finder) of the scene and put numbers to the plants.

Label all specimens as collected with consecutive numbers, and subsequently with permanent labels (about 3×2 inches) giving name of herbarium, collection, tour or district in which they were collected, date, locality, and collector, as well as the number, *e.g.*

HERB. PERADEN.

Willis, Podostemaceae Indicae, No. 55.

Hydrobryum sessile, Willis !

S. India, on rocks in river at Beltangadi,
South Kanara. 10 Nov. 1900.

Coll. C. A. Barber (No. 2520, S. Ind. Flora).

The ! following the name indicates personal verification of the identity of the specimen.

As each specimen is gathered, record the date, exact locality, elevation above sea-level, habit, colour of flower and fruit, scent, presence or absence of honey, floral mechanism, insect visits, and any other features and facts that cannot be ascertained from the specimens preserved.

Note the comparative frequency of each species, the kind of situation and soil it affects, and the species with which it is found in association.

Endeavour to note the chief general forms of vegetation and the local grouping of plants in the district studied. Pay special attention to the ecological and geographical questions suggested above under Field Work.

Record all native names (question several different individuals before deciding), economic uses, and other points of general or ethnological interest.

Further details of the subjects treated in this section may be found in the *Admiralty Manual of Scientific Enquiry*, Dammer's *Handbuch für Pflanzensammler*, Stuttgart, 1891, Asa Gray's *Structural Botany*, &c.

PART I.

OUTLINES OF THE MORPHOLOGY, NATURAL HISTORY, CLASSIFICATION, GEOGRAPHICAL DISTRIBUTION AND ECONOMIC USES OF THE FLOWERING PLANTS AND FERNS.

CHAPTER I.

OUTLINES OF THE GENERAL MORPHOLOGY, PHYSIOLOGY, AND NATURAL HISTORY OF FLOWERING PLANTS AND FERNS.

THE following account is designed as a guide to the systematic study of these subjects; the examples quoted are described at greater length in Part II., and the whole is arranged for convenience of cross-reference. Further detail may be found by advanced students in the various books and papers mentioned. The beginner should omit the section on general principles, except its first and last paragraphs, at his first reading, and return to it when he has worked through the other sections on Vegetative and Reproductive Organs.

GENERAL PRINCIPLES.

Structure and Function. There is reason to believe that the great number and variety of plants now existing have arisen by a process of evolution or gradual modification from a few simpler forms. The great feature of this evolution has been the increasing complexity of the individual plant, as of the whole vegetable kingdom; in place of simple often almost homogeneous organisms, any part of which may perform any function that may be required, there now exist also a great many complex heterogeneous organisms, with many different parts or *organs* performing different functions, a specialisation which evidently tends to greater efficiency in the performance of those functions. There is, in fact, a *functional or physiological division of labour, accompanied by a structural or morphological differentiation of organs.* To investigate the functions of plants and their gradual differentiation and perfection is the province of *physiology*[1], to do the same for the organs that of *morphology*, which seeks to know and interpret the structure and development of all organs, to trace and explain their origin, descent and modifications (*i.e.* their *phylogeny*) and to group them according to their natural relationships to one another by descent.

Not only do differentiations of structure and function go hand in hand, but also changes of these features, which may be brought about, for example, by change of climate or soil, or by other circumstances. In many cases we can see this change of structure or *metamorphosis* actually occurring in connection with a functional change, *e.g.* in Astragalus, where a leaf changes to a thorn, in Geum, where a style changes to a hook, and in the formation of fruits. Mutilation may bring about metamorphosis, as in Abies, or attacks of fungi, as in the formation of witches' brooms on trees (Chap. III.). In most trees in cold climates, the last-formed exposed leaves in autumn are bud-scales, or leaves whose peculiar form is due to enlargement of the base and suppression of the blade of an ordinary leaf during its growth; the function of these scales is to protect the bud during the winter. This leads on to the case of "successive" metamorphosis shown by such water plants as Littorella and Polygonum, where if a plant become submerged which was before exposed, it produces new leaves structurally and functionally suited to the new conditions, but does not alter the old ones. Here we can still see the change occur, but there are also innumerable other cases where we cannot do so, but where we find an organ performing a different function and possessing a different structure from those of the organ from which the general evidence shows it to be descended; thus an organ that is descended from a true leaf may have the function and structure of a root, as in Salvinia. Other instances are the leaf-like roots

[1] Comparative physiology is as yet, however, in a very early stage.

of many Podostemaceae, the leaf-like stems of Ruscus and the root-like stems of Psilotum. Here we cannot absolutely prove that a metamorphosis has occurred during or in the phylogeny, but the general evidence favours such an assumption. The important point now is that the actual function performed by an organ is no proof of its phylogenetic structural nature. The majority of organs now absorbing water from the soil are roots, in all probability lineally descended from the original roots that were first differentiated to perform the water-absorbing function ; but other organs are at times found doing this work, with their structure correspondingly changed.

While differentiation and change of function go hand in hand with differentiation and change of structure, we do not know which is cause and which effect. Most probably, perhaps, neither is, but both are phenomena of some more general law. They are however the great features of evolution and should be studied together[1].

We have now to consider how they work. If all organisms of the same kind were alike in structure and function, and offspring like their parents, progress would not be possible, but this is not the case, and the *variation* that exists forms the basis for change and evolution.

Variation. No two organisms or organs are exactly alike, even though they be the offspring of the same parent. Whatever character be chosen, examination of a large number of cases will show that it varies in degree of development in different individuals. The study of variation has received less attention than it deserves, considering that upon it rests the whole theory of evolution ; recently however important work has been done. To formulate laws of variation in the present state of our knowledge is almost impossible, but a few important generalisations have been made.

In any character whose value can be numerically expressed, *e.g.* the height of the individual, it is found that

[1] And see Goebel, *Organography of Plants*, Engl. ed.; Asa Gray, *Structural Botany* (formal non-evolutionary morphology); Sachs, *Lectures on Physiology*, Engl. ed. (a rebound to the opposite extreme of physiological morphology); Sachs, *History of Botany*.

if a sufficiently large number of individuals be measured, and a sufficiently small unit of measurement be used, the amount and nature of the variations can usually be expressed by a simple curve, rising from zero to a maximum and falling off again to zero on the other side. Thus the lengths of the lowest fruits of 568 plants of *Œnothera lamarckiana* were measured by De Vries with the following result, the upper figures being the lengths in mm., the lower the number of fruits of those lengths.

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	1	5	11	17	27	37	62	74	83	79	51	43	32	18	13	5	5	3	1

Thus the greatest number of fruits have the mean length, and the figures are evenly grouped about this mean. Such variation is called *continuous*, and the curve is known as a binomial, Galtonian, or Newtonian curve, or curve of Frequency of Error.

Frequently it happens that when a curve is plotted from a given character, it shows two or more humps or maxima, *e.g.* in a lot of *Chrysanthemum segetum* a counting of numbers of ray-florets gave maxima at 13 and 21 with a fall between. This is *discontinuous* variation, and indicates a mixture of two races, each with its own mean for the character in question. Seeds from 11—14-flowered forms gave a set of plants whose rays varied simply about 13. The important question now in dispute is whether this discontinuity arises from continuity by continuous infinitesimal stages, or by distinct steps. Such "step-variations," in which one or more individuals appear with a variation not connected by continuous intermediate stages with the other individuals of the species, are termed *sports* (or, on one view, *mutations*), and if they be of a very pronounced nature may be *monstrosities*. Monstrosities graduate into sports by easy stages and it is difficult sometimes to decide under which head to class a given variation[1].

[1] The study of monstrosities is termed *teratology*, and was formerly much employed in the decision of morphological problems. Thus the frequent occurrence of green leaves in place of carpels was regarded as a proof of the derivation of the latter from leaves, the *doubling* of a flower (*i.e.* the change of its stamens into petals) as a proof of the

It is evident, then, that in studying a plant or an organ, we must examine a number of individuals to be sure that we are dealing with an average form, not with extremes or sports.

A very important factor in variation problems is what is termed *correlated variation*. By this is meant that when an organism varies in one part, the result is frequently a variation in other parts as well, often such as have apparently no direct relationship to the first. Very probably nutrition has something to do with this; if an extra amount is diverted into any channel, as will happen in many cases of variation, the balance will have to be redressed elsewhere, and this may be the cause of further variations. No rules can be formulated about variation of this kind, but there are many cases which seem only explicable by assuming correlation.

As to the causes of variation, we know little. The mixing of parental characters in generation, and change of external conditions of life, are probably among the most active. The extent of the permanent influence of the external conditions upon plant-structure has yet to be investigated. So far as we can judge, favourable, unfavourable, and indifferent variations appear. Variation thus provides a basis for structural and functional change, and we have now to consider how the latter may be effected[1].

Rate of Increase. Every kind of animal and plant produces so many offspring that if nothing interfered with their growth and propagation they would soon cover the globe. As the average number of representatives of each

derivation of stamens from petals and so on. Other common monstrosities are *fasciation*, often found in buttercups, &c. and hereditary in the garden cockscomb (Celosia, *q.v.*), in which the stems and branches are laterally united, forming a flat structure, *peloria* (see Scrophulariaceae), and *prolification*, or formation of buds in the axils of floral leaves. The evidence of monstrosities can only be regarded as useful in solving morphological problems when a series of stages can be found between the monstrous and the normal forms.

[1] And see Darwin, *Origin of Species*, *Variation of Animals and Plants*, *Descent of Man*; Wallace, *Darwinism*; Bateson, *Variation*; Galton, *Natural Inheritance*; De Vries, *Die Mutations-theorie*; Davenport, *Statistical Methods*; Vernon, *Variation in Animals and Plants*; &c.

kind remains fairly constant from year to year, it is evident that a vast amount of destruction must take place, and that only a few of the offspring of each generation survive. The destruction is effected by animal enemies, parasitic enemies, competition with other individuals of the same or different kinds, unfavourable conditions of climate or environment, &c. When a species is transferred to a new country the balance that existed in its former habitat between its rates of increase and destruction is interfered with, often in a favourable direction, as is illustrated by the multiplication of rabbits in Australia, of Elodea in Britain, of cardoons on the Pampas. On the other hand many species are unable to establish themselves in new countries, even though, as far as we can judge, the conditions of life are as favourable as in their old localities.

Struggle for Existence. It follows that there must be among plants and animals a continual struggle for existence and propagation, both against one another and against the external conditions of life, keener between individuals of the same kind than between those of different kinds, but occurring wherever individuals are so close together as to compete for soil, light, air, or other necessaries. There may even be competition between plants far apart, for the services of insects. In deserts, arctic countries, and similar situations, the struggle is rather between plant and climate or environment, than between plant and plant, as the individuals are not usually close together.

We have now to consider what determines which individuals are to succeed, and which to perish.

Natural Selection. If there were no variation among the individuals of a species, there would be a 'survival of the accidentally favoured,' but when variation enters into the problem the result is different. Those individuals which are superior to their fellows in any character or sum of characters (not necessarily all favourable) that is of importance in the general conditions of life, *e.g.* by giving increased economy or efficiency, or by protecting against risk or danger, will on the whole be the survivors, and there will thus be a *survival of the fittest*, or a *natural selection*, analogous to the artificial selection employed by breeders, who select in each generation the finest and most suitable individuals to propagate their race. The survival of accidentally favoured individuals will also occur, but in the long run the effect of this factor will be *nil*, as it will sometimes select better, sometimes worse, individuals. The importance to an animal or plant of even a slight variation can only be appreciated after considerable familiarity with outdoor natural history has been attained, and even then only in a few cases. The very delicate adjustment of the balance subsisting between the various organisms of a district and between them and their surroundings may be disturbed even by the most apparently trivial causes. We know for instance that the weight of the individual seeds in any given species is variable; now heavy seeds give stronger plants, and hence, as offspring tend to inherit the parental characters, the weight of the seed may tend to increase in each generation, until further increase becomes disadvantageous, either directly or by producing correlated effects on some other structure or function in the plant.

Many recent authors (cf. works mentioned under Variation) deny that continuous variations can be thus permanently accumulated, and base evolution upon discontinuous variation, but for our purpose it is sufficient that variations can be accumulated and in time produce such alteration in structure and function that it may be extremely hard to trace the phylogeny of an organ or plant (cf. Chap. II.).

Structural and Functional Characters; Adaptation; Ecology. It is evident that every existing plant or species must be fairly well suited to its surroundings, but not necessarily perfectly so; if it be very well suited to existence amid such environment, it will probably increase in numbers, if not, it will probably decrease, and perhaps ultimately become extinct. Its characters are, as we have seen, derived from pre-existing forms, but a certain number of them will have been recently acquired in the evolution that has occurred. These will often be characters suiting it more closely to the circumstances under which its life is carried on, and if hereditary and of direct use in the life-history, may be called adaptive characters, or *adaptations* to the mode of life. As time goes on, if the descendants continue to live in similar environments, the adaptive characters may become more and more pronounced. At the same time it must be clearly recognized that while on the whole disadvantageous characters tend to disappear, there are probably great numbers of them in existence; the plants which possess them may overbalance them with advantageous characters, or may be slowly dying out in consequence of them. A plant or species will win or lose in the struggle for existence on the *total* of all its characters. Correlation may possibly produce disadvantageous characters at the same time as advantageous, or a given cause acting on different organs of the plant may possibly produce advantageous variations in some, disadvantageous in others.

It is very difficult to decide which if any of the characters of a plant or species are adaptations to its mode of life. A species may possess some character admirably suiting it for one mode of life, though acquired for some other, and if it be found living in the former mode we shall be liable to mistake this character for an adaptation to that mode of life. Examples of this are given in Chap. III. under Epiphytism. Or again, a species may possess some character of little or no importance in its mode of life but which may prove of great importance in some other environment, should it happen to be placed there.

The study of adaptation is carried on by the comparison of all forms living in similar surroundings, *e.g.* all water-plants, or all parasites, &c. The members of these ecological groups of plants belong usually to many distinct families and their retained ancestral characters therefore differ; if now we find among such a group certain characters in common, which are hereditary and are useful in the particular mode of life characteristic of the group, we may feel pretty sure that we are dealing with genuine adaptations. In such comparative study too, it is brought out in a very striking manner that the same end is attained in a great variety of ways, *e.g.* different organs in different species may be modified in their descendants in such a way as to resemble one another in structure and function. Good examples of this may be found among xerophytes (Chap. III.), *e.g.* by comparing the various ways in which storage of water, or reduction of the transpiring surface, is effected.

The science of ecology has to deal with all the characters of a plant, structural and functional, in relation to the environment and the struggle for existence, and determine which are helpful, which hurtful, and to what extent. It is bound up with the study of geographical distribution, and intimately related to morphology on the one hand, physiology on the other[1].

We have now to return to morphology and consider its methods. The actual ancestral forms of any given plant being lost, other ways of tracing the phylogeny must be employed.

Comparison with related forms is the method chiefly used in deducing phylogenies. If a given plant *X* be the immediate parent of several plants *A*, *B*, *C*, *D*, we know that these will resemble one another, as well as *X*, in detail, allowing for variation; they are exactly equivalent to one another by descent. We now transfer this idea of equivalence to their organs, and say that those of *A* are equivalent by descent to the corresponding organs of *B*, *C*, *D*, or *homologous* with them, and we extend the idea to the ancestral forms, and say that they are also homologous with the corresponding organs of *X*, and with those of *Y*, a more remote ancestor, but the further back we go, the more change there may have been, and the less exact will the correspondence be. Even between *A* and *B*, the homology must not be pressed too closely into minute detail, *e.g.* while the primary roots may be exactly homologous, the hairs on the leaves will only be 'generally' homologous.

If *A*, *B*, *C*, *D* are not the offspring of a single parent, but agree closely in all characters, we yet assume, on the general theory of descent, that they had a common ancestor, *Y*, not very far back. We therefore regard them as equivalent, and their corresponding organs as homologous. We further assume that the characters in which they agree exactly are characters derived from *Y*, and we can thus infer what *Y* was like.

Now suppose that the lateral organs of the shoot in *A* are tendrils, in *B* thorns, in *C* and *D* leaves, while in all other characters the four agree. We may still say that the

[1] And see books mentioned under Variation; Goebel, *Organography of Plants*; Warming, *Oekologische Pflanzengeographie*; Willis, *Podostemaceae*, Ann. Perad. I. 1903, pp. 417, 444, &c.

tendrils, thorns, and leaves, agreeing in position, mode of origin, &c. upon closely related plants, are mutually homologous. During the descent from *Y* change of structure and function has gone on in at least two of the lines, as there are now three types of structure and function. As *C* and *D* have leaves, the probability is that *Y* had leaves also, and that the organs of *A* and *B* are 'modified' leaves, but to confirm this supposition we must examine other nearly related forms *E*, *F*, *G*, *H*, &c. If all these have leaves, then probably *Z*, the common ancestor of these and of *A*, *B*, *C*, *D*, had also leaves. *Z* may be the same as *Y*, but probably is older; in any case, however, the supposition that *Y* had leaves is strengthened. The points in which *A*, *B*, *C*, *D*, *E*, &c. all agree will in general be those handed down from *Z*.

Evidently, then, the more that the plants examined differ, the further back will be the ancestral form, the less can we infer about that form, and the greater will be the difficulty of tracing the phylogenies and the homologies. We must also be careful in using such expressions as 'modified leaf.'

Position, Mode of Origin, and Internal Structure are characters of very great importance in morphological comparisons, and are largely used in practice. Homologous organs often agree in these characters, if in no others, *e.g.* 'shoot-branches' usually arise in leaf-axils, exogenously, and have 'shoot' anatomy, though they may actually be tendrils or thorns.

Development of the individual organ from the embryonic condition, *i.e.* its *ontogeny*, often affords useful aid in tracing phylogenies and homologies. Such investigations need the aid of the microscope, must be comparative, and their results must be tested by those of other methods. Speaking broadly, allowing for exceptions and variation in detail, it may be said that the metamorphoses of the ontogeny tend to recapitulate those of the phylogeny. The more recent the latter, the more clearly they will show in the former, while the earlier stages will tend to run rapidly into one another. Suppose two organs of common descent to have passed through phylogenetic changes represented by *ABCDEFGHKL* and *ABCDEMNOPQ*, then their ontogenetic phases will be represented roughly by A B C D E F G H K L and A B C D E M N O P Q, the larger type and spacing indicating greater distinctness and duration. Like other methods, development is most valuable in the investigation of recent phylogenetic changes[1].

Seedling Stages: Reversions: Polymorphism. In plants which when mature differ in morphological habit from their related forms, interesting phases of successive metamorphosis are often shown in the seedlings; this is simply a special case of the ontogenetic recapitulation above mentioned. Good instances are Acacia, Bossiaea, Ulex, Hakea, many succulents, water-plants, &c.; see also Retinispora, and cf. expanding buds of Acer, Aesculus, Berberis. In many respects the characters of seedlings are of special importance in comparative morphology.

Single branches of mature plants at times show similar transitional or apparently ancestral phases of structure, *e.g.* in Acacia, Russellia, &c. Care must be taken, by employment of comparison and other methods, to confirm any deductions from such phenomena. If confirmed as probably ancestral, we may call them *reversions* or 'returns' to the ancestral type (*atavism*); if not confirmed by other evidence, they may be sports or monstrosities (above), or may be cases of *dimorphism* or *polymorphism*. Many organs appear in two or many forms on the same plant or on different plants of the same species; instances are the dimorphic shoots of Hedera and other climbers, leaves of many epiphytes and water-plants (Chap. III.), unisexual flowers, heterostyled (Lythrum) or right and left handed (Saintpaulia, Exacum) flowers, the flowers of Catasetum, &c.

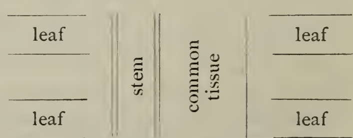
Multiple Origin and Parallel Descent are phenomena which appear to have been common in plants, and which increase the difficulties of morphological as of taxonomic study. Organs may appear alike in position, structure, function, and mode of origin, and yet not be phylogenetically homologous. Thus the leaves of mosses are not homologous with those of Selaginellas, having a totally different ancestry. In the case of adventitious

[1] And see Goebel, *Organography of Plants*, and *Entwicklungsgeschichte der Pflanzenorgane* (Schenk's Handbuch der Bot.).

roots (see below) organs similar in structure, function, development, and position appear to have arisen in similar ways in various groups of plants, *i.e.* in various lines of descent or *phyla*; in each group the roots are mutually homologous, but the whole class of "adventitious roots" is *polyphyletic*, and the roots in different groups are only *homoplastic*, *i.e.* equivalent in structure and mode of origin on the plant, but not of common (though of parallel) descent. If we can also prove common descent they are of course homologous. Homoplastic organs must not be confused with *analogous* organs, which agree in function but not in descent nor mode of origin nor position, *e.g.* the root-like leaves of Salvinia are analogous to roots.

As in taxonomic work (Chap. II.) so in morphological, care must be taken to work with the aggregate of all the characters of an organ and to use comparison extensively, otherwise these phenomena of multiple origin (*polyphyly*) and parallel descent (*homoplasy*) are liable to cause error and confusion[1].

Concrescence, or union of originally distinct organs by growth of the tissue beneath them, is a common phenomenon of structure. Organs in their earliest stages of development are usually separate, and most often remain so, but frequently there is a subsequent uniform growth of the tissue under them, carrying them out upon a basal portion which most often (*e.g.* in sympetalous flowers) has a similar structure to the organs themselves, so that they look as if joined together by their bases. The diagram shows this process on the right, but not on the left. It is common in flowers, less so in other organs. It is not necessary for the concrescent organs to be similar; *e.g.* stamens are often united to petals, leaves to stems (cf. Solanaceae, &c.). The phenomenon goes under many names—adnation, connation, adhesion, cohesion, &c. (see below).



[1] Bower, *Presidential Address*, Brit. Ass. Rep. 1898; Willis, *Podostemaceae* (§ on dorsiventrality), Ann. Perad. I. 1902, pp. 411, 446.

Abortion and Suppression of organs are other common phenomena. In a certain place in a certain plant, comparison with related forms often shows that we should expect to find a certain organ, say a stamen; instead of this we find a small functionless rudiment due to arrested development (*abortion*), or nothing at all (*suppression*). These phenomena may be both onto- and phylo-genetic, *i.e.* may occur in a single individual without being necessarily hereditary, or regularly and hereditarily in all individuals of a species. The importance of aborted (also called *vestigial* or *rudimentary*) organs in morphological and taxonomic study is considerable, as affording useful clues in phylogeny. The abortion or suppression may be due to loss of function, disadvantageousness of the organ, correlation, mutation, or other causes.

Symmetry. It rarely happens that an organ (or plant) is *asymmetrical*, *i.e.* so constructed that it cannot be divided in at least one direction into two halves one of which is the counterpart or reflection of the other (cf. leaves of Begonia, flowers of Valerianaceae). Complete spherical symmetry is rare except among very lowly forms of life, but what is termed *radial* (or better *multilateral*) symmetry, such that any plane passing through the axis of growth of an organ and through one of the lateral branches of that organ, divides it into complementary halves, is common, *e.g.* in roots, erect stems, many flowers (*actinomorphic*, cf. diagram in Rosaceae) &c. Another frequent type of symmetry is *bilateral*, in which only one axial plane divides the organ evenly, *e.g.* in many flowers (*zygomorphic*, cf. diagrams in Labiatae, Orchidaceae), leaves of Iris, &c. A special case of this is *dorsiventral* symmetry, in which the organ has an upper or *ventral* side different from the lower or *dorsal*, as in most leaves, most zygomorphic flowers, many horizontal shoots, &c.[1]

Classification of Organs. General comparison shows that certain structural characters are almost universal among the higher plants, and therefore to be regarded, on the principles indicated above, as derived from a very

[1] Goebel, *Organography of Plants*, Engl. ed., p. 65; Willis, *Podostemaceae* (dorsiventrality) in Ann. Perad. I. 1902, p. 434.

distant ancestry. Almost all show distinction into *root* and *shoot*; the reproductive function accompanies the latter, the former absorbs water from the soil. The shoot is nearly always divided into a reproductive part or *inflorescence*, and a non-reproductive part performing vegetative duties (see below). It is also usually divided into stem and leaf in both parts. It is convenient and fairly accurate, therefore, to divide the organs of plants into *reproductive*, concerned with the life of the race (inflorescence, flower, fruit, seed), and *vegetative*, concerned with the life of the individual (root, stem, foliage-leaf). Hard and fast lines cannot be drawn. Vegetative reproduction (see below) is common, and in many ferns &c. the reproductive and vegetative functions are performed by the same leaves.

Vegetative Organs.

The distinctions between root, stem, and leaf are not always easy to draw (cf. Anthurium, Neottia, Podostemaceae, Utricularia). The two last may best be considered together under the common term *shoot*, the distinction between which and the *root* is usually clearly marked even in the embryo. The root usually grows downwards into the substratum for the purposes of absorbing food substances and of anchoring the plant; does not bear leaves nor the true reproductive organs, is endogenously branched, and usually bears a root-cap (see below). The shoot on the other hand (or part of it) usually grows above ground and consists in part of green tissue performing assimilatory functions; it often bears leaves, and always the true reproductive organs, is exogenously branched, and has no cap. We shall first deal briefly with the vegetative functions, and then with the organs and their structure.

Nutrition, Transpiration, Respiration, Metabolism. Most plants have green shoots or leaves, and in them the processes of nutrition are in general those described below; the peculiarities of parasites &c. are described in Chap. III.

Nearly all higher plants have roots or analogous organs in the soil (cf. water-plants, epiphytes, parasites, in Chap. III.). The water in the soil is held by capillary attraction, and dissolves carbonates, nitrates, and other salts. The dilute solution is absorbed by the root, and the plant thus obtains nine of the ten elements that it needs, viz. nitrogen, hydrogen, oxygen, phosphorus, sulphur, iron, magnesium, calcium, potassium. Silicon, sodium, chlorine and others are usually absorbed also, but though often incidentally useful (*e.g.* silica in stiffening grass stems) are not absolutely necessary. The tenth element, carbon, is obtained from the carbon dioxide of the air. In presence of sufficiently bright light, this gas is decomposed by aid of the green colouring matter (*chlorophyll*) in the leaves &c.; oxygen is given off, and the carbon worked up into complex organic compounds, the process being termed *assimilation.*

Water is continually evaporating from the subaerial organs, especially the leaves. This *transpiration* is made good by the current that flows from the root upwards, bringing with it to the leaves the mineral salts absorbed by the root. The current travels in the *wood* or *xylem* of the *vascular bundles* of the plant; the bundles form the bulk of most roots and stems, and appear in the leaves as *veins* or *nerves.*

Respiration, or absorption of oxygen and evolution of carbon dioxide, is carried on in living parts of plants, as in animals.

Assimilation goes on in the leaves and new living substance, or *protoplasm*, is made, which as fast as it is formed decomposes into simpler substances, chiefly sugar and amides, which are carried away by the *phloem* or *bast* of the vascular bundles to those parts of the plant where they are required. This continual chemical change is termed *metabolism*, and may be divided into *anabolism*, the building up, and *katabolism*, the breaking down, of complex materials. The materials carried away in the phloem are used at once at the growing parts or as food by the living cells, or else they are stored up as *reserves* for future use. All seeds contain reserves and so do all plants which die down at any period of the year or are arrested in their growth by cold or drought. Reserves are also made in many cases (Agave, many Palms, &c.) to enable the plant to produce a great mass of flowers and seeds at some future time.

No accumulation of the products of the different steps in anabolism takes place, the upward progress to protoplasm being gone through very rapidly, but with katabolism it is different and accumulations of the products occur. The first downward step is the decomposition of protoplasm into *proteids* (complex organic bodies containing carbon, hydrogen, oxygen, and nitrogen); the next is to *amides* (crystallisable organic bodies, containing the same elements; the commonest is asparagin); then, by elimination of nitrogen, the *carbohydrates* (bodies containing carbon, hydrogen and oxygen in the proportions $C_xH_{2y}O_y$; the chief are starch, cane-sugar, grape-sugar or glucose, mannite, inulin, and cellulose), the *oils* or fats (containing C, H, O), *tannins*, and other bodies, are formed. A further decomposition may take place, in respiration (which is the expression of katabolism), giving as final products carbon dioxide and water. All the products mentioned so far are capable of being used again in the metabolism of the plant, but there are others which are apparently waste-products. Only rarely are these excreted at the surface; usually they are stored in the cells or in special cavities or passages. Some of these bodies are of economic value, *e.g.* resins, alkaloids, ethereal oils, wax, &c.

In forming reserves the plant always stores up both nitrogenous and non-nitrogenous materials. The former take the shape of proteids in seeds; in other places they may be proteids or amides. In seeds the latter are usually stored as starch or cellulose (*starchy* seeds) or as oils (*oily* seeds); in other places other forms occur. In germination ferment-action causes the decomposition of the reserves and their transmutation into sugar and amides, in which forms they travel through the plant.

Growth, usually implying increase in size and weight, but better defined as permanent change of form, is a feature of all living plants and organs. In those with which we have to deal, growth is only general in the whole plant in the earlier embryonic condition, and subsequently becomes localised in certain *growing points*, *e.g.* at the tips of stems and roots, and *growing layers*, *e.g.* the *cambium* by whose means stems and roots grow in thickness. The new tissues and organs formed in these places expand to their full size and then usually cease to grow.

Growth takes place only under suitable conditions, viz. (1) a supply of material to the growing parts, (2) a supply of energy, (3) an adequate temperature, and (4), in most cases, a supply of sufficient water to the growing parts to maintain the cells in a condition of great turgidity or tension. The supply of material is brought from the leaves or from storage places; the energy is obtained from this; that an adequate temperature is necessary is a familiar annual experience in temperate countries: and that turgidity is needful is easily proved by simple experiments, and indicated by the fact that a plant will not grow unless well supplied with water.

The rapidity of growth depends on various factors, some external, some internal. Light retards growth, as is proved by measurement of the rate of growth of the same plant during day and night, and as is also evidenced by the phenomena of *etiolation* (growth of green plants in darkness; under these circumstances the shoots grow rapidly, but are very slender, the leaves small and far apart; chlorophyll is not developed, but a yellow matter termed *etiolin* is). Below a certain temperature (varying according to the plant and the climate) growth will not take place. As the temperature rises from this minimum, the rate of growth increases, till it reaches its maximum at a temperature which is termed the *optimum* temperature for growth in that plant; as the temperature rises beyond this, growth decreases, till a maximum temperature is reached, beyond which growth will no longer go on[1]. The rate of growth is also affected by conditions internal to the plant, especially the amount of food supply and the rapidity with which it is made available. The growth of seedlings or of buds opening in spring is usually more rapid than that of parts which have not the advantage of a rush of food from some reserve store, but depend upon that provided from day to day by the leaves.

The direction of growth, unless influenced by greater stimuli on one side of the organ, is usually straight forward, but the tip commonly *nutates*, *i.e.* moves alternately from side to side or round an elliptical or circular orbit, owing to varying rate of growth of the tissues: as the growth becomes

[1] Most plant functions show similar *tonic* effects of temperature.

complete the organ assumes the straight line. Nutation is most marked in climbing plants (Chap. III.).

Irritability; Movements; Orientation. Living protoplasm is sensitive or *irritable* to many stimuli. In higher plants, this sensitiveness is chiefly shown in *movements of growing organs* which tend to grow in such a way as to take up definite positions (or *orientate* themselves) with regard to the incidence of the stimuli acting upon them. The orientation generally depends on the symmetry; a radial organ usually places itself in line with (or is *orthotropic* to) a stimulus, a dorsiventral organ at right angles (*plagiotropic*) to it. If the direction of the stimulus change, the growing point curves to reassume the proper orientation, as is seen in plants curving towards light in a window. Two cases of orthotropism must be distinguished, *positive* (growth towards) and *negative* (growth away from the stimulus). The different irritabilities have special names, viz. *heliotropism* (light), *geotropism* (gravity), *hydrotropism* (moisture), *chemotropism* or *chemotaxis* (chemical stimulus), *rheotropism* (water current), &c. Sensitiveness to contact stimulus is found in some cases, but almost solely in climbing plants, and there more especially in tendrils (see Chap. III.).

An organ is described as *heliotropic* or *positively heliotropic* if it grow directly towards light, *negatively* or *apo-heliotropic* if directly away from it, *plagio-* or *dia-heliotropic* if at right angles to it; similar expressions are used for the other irritabilities.

Movement of *mature* organs is found chiefly in leaves (see below), and in some stamens, flowers, &c. (see Flower-mechanisms, below).

The Root. The 'true' root of a higher plant is the organ descended from the original absorptive organ first differentiated from the shoot. In the vast majority of these plants it is present in the embryo, starting at one pole while the shoot starts at the other. Its structure may be studied in seedlings of beans, gourds (fig. 1), mustard, &c. The embryo plant in the seed has a short shoot-axis or *hypocotyl*, at the upper end of which are two *seed-leaves* or *cotyledons* and a small stem-bud or *plumule*, while at the lower end there is a short *radicle*, which grows out to form the *primary root*. In systematic descriptions the term radicle generally includes the hypocotyl; the two are usually indistinguishable except by the internal structure. The primary root is strongly geotropic and hydrotropic, and negatively helio-

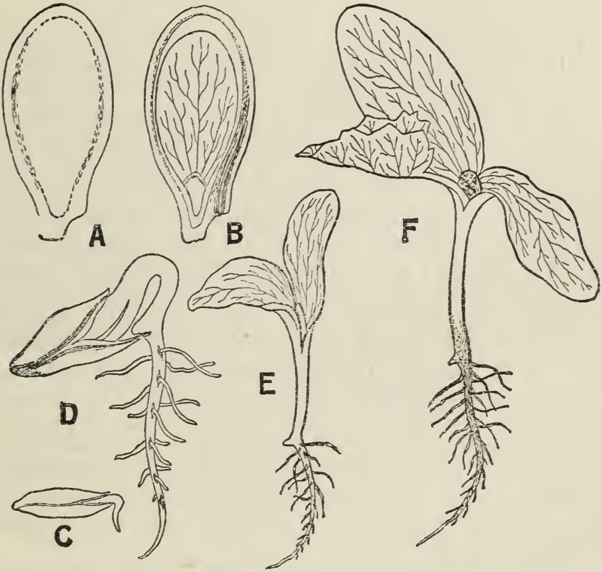


FIG. 1. GERMINATION OF GOURD (CUCURBITA, q.v.).

A, the seed. *B*, seed laid open, showing one veined cotyledon and the hypocotyl-radicle. *C*, the radicle, by the growth of the hypocotyl, has emerged from the seed-coat and is growing down geotropically. *D*, the peg has caught on the seed-coat, while the growth of the arched hypocotyl has nearly freed the cotyledons. *E*, the cotyledons are freed and the hypocotyl has become straight. *F*, the first foliage-leaf has developed from the plumule.

tropic; it therefore grows on the whole straight downwards, but may curve towards moisture.

The tip of the growing point is covered by the *root-cap*, an organ peculiar to roots, consisting of a sheath of cells that is continually renewed from within as it wears away outside, like the skin of the hand. It protects the delicate growing point from injury as it is pushed through the soil. Only rarely (cf. Pandanaceae, Lemna) is the cap distinguishable by the naked eye. It is absent in Azolla, Neottia, &c. (adventitious roots).

From the main root of a gourd or bean there sprout lateral roots arranged in four vertical ranks. This is due to the fact that they arise deep down in the main root, at points opposite to the xylem bundles, of which there are four (in these plants). The young root burrows its way out into the soil through the outer tissue of the parent root; such development is termed *endogenous*, in contrast to *exogenous* development, from superficial tissue. The lateral roots are arranged in a definite order of age, the youngest being nearest to the apex of the main root; this is termed arrangement in *acropetal succession.* They are but little sensitive to gravity and grow more or less horizontally, but are governed in their growth by definite though ill-understood laws. If, for instance, the northward growth of one of them be interrupted by a stone, the root, as soon as it has reached the edge of the obstacle, tends to resume that direction of growth. This tendency of lateral roots to grow away from the main root is termed *exotropism* and is of importance to the root by enabling it to spread in all directions through the soil in which it is growing. The lateral roots may be again branched and so on.

If, as in the bean, the main root grows to be much longer than the branches, it is termed the *tap-root.*

The functions most characteristic of roots are the absorption of food-materials from the substratum, and the anchorage of the plant therein. The former is generally effected by the agency of the fine unicellular *root-hairs* which clothe the tips of the roots a little way behind the actual apex (easily seen in mustard seedlings or in many water roots). The branching and mode of growth of the root admirably fit it for the absorption of all the food-materials obtainable in the soil in which it grows. In saprophytic plants (see Chap. III.) the root absorbs the products of decaying organic matter (*humus*) from the soil, as well as mineral salts. In most of our forest trees and in many other plants, the root hairs are replaced by a fungus whose hyphae absorb in the same way. This is termed a *mycorhiza*; in the Fagaceae, Betulaceae, Coniferae, &c. it is *ectotropic*, *i.e.* the hyphae do not enter the cells of the root but run between the epidermal cells, whilst in Orchidaceae, Ericaceae, &c. it is *endotropic*, the hyphae entering the cells. Mention may also be made of the tubercles of the roots of Leguminosae (q.v.) and other plants. In a few cases the roots are *parasitic* upon other roots living in the same soil, and are modified in structure to suit this modification of their absorptive functions (cf. Chap. III.). The second function, anchorage of the plant, is admirably effected by the branching and arrangement of the roots, aided by their internal mechanical adaptation, the vascular tissue being centrally placed so as best to resist a longitudinal strain. The growth in thickness of the root keeps pace with that of the stem. In many large trees the growth in thickness of the lateral roots at the base of the trunk is chiefly vertical, and 'buttress' roots are thus formed, *e.g.* in Ficus.

A function often performed by roots, and one which is accompanied by serious modifications in their structure, is storage of reserve-materials to enable the plant to start growth in the wet season, or in the next spring, &c. (p. 33, and see Herbs in Chap. III.). The root is usually thickened to contain the materials. (See Brassica, Daucus, Raphanus, Taraxacum, &c.).

In nearly all cases true roots perform normal root-functions and have normal structure, exhibiting little variety. In a few plants, *e.g.* Utricularia, Aldrovanda, Psilotum, Salvinia, there is no primary root, and its function (and often structure) is found in analogous organs (p. 32). In many other cases the primary root does not develope very far, and its functions are discharged by organs having the structure, physiology, and endogenous development of branch roots, but developed from the stem or leaves. These organs are not homologous by descent with true primary roots, and are classed as *adventitious roots*. In dealing with the homologies of these organs among themselves we can rarely go beyond the immediate circle of relationship of the plants in which they occur; the class is almost certainly polyphyletic (p. 30); *e.g.* we have no right to say that the adventitious roots of the Palms are homologous with those of the Podostemaceae.

When they arise below ground, as in grasses, bulbs, &c., these roots generally have the structure and function of true roots, but when they arise above ground (*aerial roots*) they often perform new functions and have other structure.

Subterranean adventitious roots may be in tufts of uniform length, as in grasses (*fibrous* roots); *tuberous* for storing reserves (Ranunculaceae, Orchis); *parasitic* or *saprophytic* (Chap. III.); or may give off subaerial *aerating* branches (mangroves, Chap. III., and cf. Rumex, Jussieua, Sesbania). Aerial roots may form *buttresses* (Palmae, Pandanaceae, Rhizophora, &c.) to support the stem, as well as absorbent organs; *pillars* (Araceae, Ficus, &c.); *clasping* and *climbing organs* (Araceae, Hedera, Tecoma, Orchidaceae); *water absorbing organs* (Orchidaceae, Velloziaceae); flattened green *assimilating organs* (Podostemaceae, some Orchidaceae); *thorns* (Acanthorhiza, &c.); parasitic *suckers* (Cuscuta, Viscum, &c.), &c. See Chap. III. and Part II.

The Shoot. The primary shoot developes from the upper end of the seedling (cf. fig. 1, p. 37). The plumule or bud soon grows onwards and gives rise to a *stem* bearing *leaves* at points called *nodes*, the spaces between being *internodes*. Branches often form in the upper angles or axils between the leaves and stem. The advantages of this differentiation of the shoot into stem and leaf are great; the leaves require plenty of light and air to carry on assimilation. The stem serves as a support to spread them out for this purpose and to carry water to them, while they themselves are thin, exposing a large surface to the air and light. Often the shoot or part of it is used as a reservoir for storage of reserves. Living as it does under every variety of position, climate, and environment, the shoot is far more varied in form than the root.

The symmetry of the mature shoot is very varied, and the orientation of different shoots and organs to the stimuli of light and gravity almost equally so. The ordinary erect stem is heliotropic, and negatively geotropic; its branches and leaves, as well as creeping stems, generally plagiotropic to these stimuli.

The Bud which crowns the tip of the stem is simply a much-condensed shoot, a short stem with crowded nodes, at which are borne young leaves. The tip of the stem is covered by the young leaves folded over it; if they be removed (as is easily done in Hippuris) the exposed apex of the stem is seen, under the microscope, to consist of a convex mass of embryonic tissue, on which lateral swellings arise *exogenously* (*i.e.* from the external layers) in acropetal succession (cf. Roots). At first all alike, these outgrowths ultimately differentiate into leaves and branches. Branches thus produced are termed *lateral* branches. Another type of branching is common in lower plants, viz. *dichotomy*, where the growing apex divides at the summit into two equal halves, but this is practically unknown in the higher plants.

The bud is very important, and from the young and tender nature of its parts is very susceptible to injury. In tropical climates with plenty of moisture it may be injured by the intense radiation decomposing its chlorophyll, or by heavy rain. In hot sun or very dry places it is further liable to excessive evaporation. In temperate climates it is often exposed to snow, rain and cold, and many buds have to survive the winter. Against these dangers buds are protected in various ways, by the older leaves, by scales, hairs, wax, &c. (see Herbs, Trees, Xerophytes, &c. in Chap. III.). Buds are often detached to start growth on their own account (vegetative reproduction, see below).

The arrangement of the leaves in the bud is called their *vernation*; it is constant for each kind of plant, and is described in the same terms as that of the flower bud (see below, Aestivation).

The Branches. At the growing apex of the stem exogenous outgrowths are formed, some of which usually develope into branches. A stem is rarely quite unbranched; it usually branches in the flowering portion if not in the vegetative. If we leave the former out of account we may say that the stem is unbranched in most Palms and many other Monocotyledons, and in a few Dicotyledons. The branching is lateral, and commonly the position of the branches bears some definite relation to that of the leaves. In many ferns the branches appear on the leaf-bases, in Equisetum they are *axillary* (*i.e.* in the angles between leaves and stem), and the same is so generally the case in flowering plants (except Pistia, &c.), that the usual mode of deciding whether a doubtful structure is of "leaf" or "stem" nature, is by noticing whether it subtends an axil or stands in one itself. In Selaginella and Lycopodium the branching has little relation to the leaves. The number of branches arising close together is usually small and most commonly only one arises at one level.

Other branches than the usual one, arising in the same place, are called *accessory*; they may be *collateral* (side by side in the same axil) as in species of Acer, Salix, &c., or *serial* (one above the other) as in Calycanthus, Gleditschia, Cercis, Robinia, Colletia, Syringa, Aristolochia, Fuchsia, &c.

Concrescence (p. 30) or *adnation* is common in shoots. The most simple case is where a leaf is 'adnate' to its own axillary shoot, so that the latter appears to spring from the main stem without reference to any leaf, and the leaf looks as if it belonged to the branch and not to the original stem. A common case is that the axillary shoot is adnate for a greater or less distance to the main shoot from which it springs; *e.g.* in Anthurium and other Araceae, Cyperaceae, Potamogetonaceae (*e.g.* Zostera), Solanaceae, Cuphea, Asclepias, &c. Some of these only show the phenomenon in the floral portion of the shoot.

Frequently a plant has branches of two kinds—*long* and *short shoots* or *shoots of unlimited* and *limited growth*. The former grow indefinitely, whereas the latter remain short, often resembling tufts of leaves. See Coniferae, Pinus, Berberis, Spergula, Cactaceae, &c.

The branch buds formed near the apex of a stem do not always develope at once. In perennials at any rate, many of them usually remain as *dormant buds*, but may start into active growth if the others are killed or injured. The branches that appear later in life from the lower parts of stems are sometimes formed from dormant buds, but often are adventitious, developed from new buds formed without reference to the old leaf-axils.

Lateral branching is generally of two types, the *monopodium* and the *sympodium*. In the former, *e.g.* Pinus and other Coniferae, the same growing point continues in a straight line from year to year and forms branches in regular succession, which do not overtop the main axis. This type is common in herbs with erect stems. The sympodium is found in most of our forest trees and in many shrubs, rhizomes, &c. Here the successive lateral branches in turn overtop and supersede the relatively main axis; the growing point, which for the time being is the main one, is pushed aside by the growth of the branch, which thus comes into line with the axis from which it sprang. The termination of the old axis is thus made to look like a branch of the straight stem. The second growing point is in turn pushed aside and so on, so that the actual straight stem is formed of a succession of pieces each added by a separate growing point. This is roughly illustrated by the diagram, each ┐ representing one *limb* of the sympodium, arising as a branch upon the one below it. Often only one limb is formed each year, and during that period branches monopodially; the last lateral bud then pushing the terminal one aside in the following year. Excellent examples of sympodia are: beech (Fagus), virginian creeper and vine (Vitis), the rhizomes of Iris, Juncus, &c., the flowering shoot of *Geranium pratense*, &c.

Growth in Thickness and Habit of Stem. Most erect stems elongate and branch; they thus increase their leaf-surface, and hence also the strain to be borne and the demand for water from the roots to supply the transpiration. To meet this, they usually grow steadily in thickness, forming new wood and bark. A large proportion of the new material in erect stems consists of woody fibres or strengthening tissue. This thickening process is rare in Monocotyledons and Pteridophyta, but occurs in a very large proportion of Gymnosperms and Dicotyledons. It is less marked in climbers, and rarer in creeping stems, small herbs, &c. (see Chap. III.).

The living cells of the stem need to respire; so long as the stem is green it has stomata in the epidermis (cf. Leaf, below), but as it grows in thickness *bark* (*cork*) is formed, and this is practically water- and air-tight. To provide for respiration special organs (*lenticels*) are formed in the bark; these are portions of bark in which the cork is loose and powdery so that air can pass. They appear upon the surface as little eruptive craters full of a brown powder, specially well seen in Elder (Sambucus) but easily distinguished upon any young twig.

Storage of reserve-materials is a function very commonly undertaken by the stem in perennial plants. In woody plants the materials for subsequent growth are usually stored in the wood of the stem, and only rarely does storage take place to such an extent as to necessitate extra growth in thickness beyond that necessary for the performance of the functions already dealt with. Cases are found in Bombacaceae, Jatropha sp., &c. Herbaceous stems above ground are not usually suited to storage purposes, though some cases occur (succulent Xerophytes, see Chap. III.), as they die down in winter (or the dry season in warm countries) and here storage is usually found below ground, in such peculiar shoots as bulbs, corms, rhizomes, tubers, &c. (see Chap. III., Herbs, Xerophytes, &c.). Such shoots also lend themselves readily to vegetative reproduction.

Other types of stem are found in water-plants, climbing plants, xerophytes, epiphytes, &c. (see Chap. III.). These illustrate the modification of structure bound up with the modification of certain functions due to varying climate or situation.

Like roots, shoots are often *adventitious* (or *secondary* if there are also primaries), arising by the budding out of growing points on roots (*e.g.* Podostemaceae, Ailanthus, Anthurium sp., and many trees), or on stems (many tropical trees, Testudinaria, &c.). Account must always be taken of such cases in dealing with homology of shoots.

The *habit* of the stem, *i.e.* its general external appearance and impression, will be dealt with in Chap. III. A number of descriptive terms, however, may conveniently be put together here.

Most of these explain themselves or are explained above and in Chap. III. Stem and leaf should always be described together for the sake of accuracy and conciseness.

Stems may be *annual*, *biennial*, or *perennial; erect*, *climbing*, *twining*, *prostrate* or *procumbent*, *creeping*, *ascending* or *decumbent* (bending upwards from a prostrate base), *floating*, &c.; they may be *unbranched* (*simple*) or *branched* (describe mode of branching); if branched they may be *caespitose* (a tuft of shoots from the base, as in many grasses), *fastigiate* (many branches parallel to the stem, as in Lombardy poplar), or with *fascicles* (tufts) of lateral branches. The stem or branches may be a *corm*, *bulb*, *tuber*, *rhizome*, *runner*, *stolon*, *sucker*, *offset*, *phylloclade*, *tendril*, &c. Adnation may occur, or long and short shoots; the stem may be a *monopodium* or a *sympodium*; it may be 'condensed' bearing 'radical' leaves, and run out into a *scape* bearing only the flowers, as in dandelion. It may be *herbaceous* (not woody above ground), *woody*, *succulent* or *fleshy ; solid*, *hollow* (*fistular* if herbaceous); *straight*, *flexuose* (zigzag), &c.; *cylindrical*, *terete* (cylindrical tapering), *angular*, *ribbed*, *winged ; smooth*, *prickly*, *warty*, *hairy* (for terms see Leaf, below). Polymorphism if any, form and texture of bud and bud-scales, growth in thickness, size and habit, bark (*smooth*, *scaly*, *warty*, &c.), colour, and other points must also be described.

Phyllotaxy, or the arrangement of the leaves upon the stem, is according to definite rules, especially in flowering-plants, though it varies within certain narrow limits.

Leaves may be several at each node, when they are said to be in *whorls*, or two at each node (usually *opposite*), or one (*alternate*). When the stem is so short that the leaves, as in the primrose or dandelion, are all crowded together and spring from the level of the ground, they are said to be '*radical.*' In the first two cases, as a rule, the leaves at one node stand above the gaps between those at the node below. In the case of alternate leaves there is found to be a fairly constant angle between each leaf and the next one above it, *e.g.* in Plantago (fig. 2) this angle is $\frac{3}{8}$ of the whole circumference measured the nearest way. This fraction $\frac{3}{8}$ represents the phyllotaxy of the plantain. A little consideration will show that (twisting of the stem excepted) the leaves will stand in 8 vertical rows, each divided from the next by $\frac{1}{8}$ of the circumference. For if we start from any leaf 1 and pass by the nearest way through all consecutive leaves till we come to leaf 9, this must be above 1 again. Leaf 2 will be $\frac{3}{8}$, 3 will be $\frac{6}{8}$, 4 will be $\frac{9}{8}$, 5 will be $\frac{12}{8}$, 6 will be $\frac{15}{8}$, 7 will be $\frac{18}{8}$, 8 will be $\frac{21}{8}$, and 9 will be $\frac{24}{8}$, of the circumference from leaf 1, *i.e.* immediately over it, and three turns of the spiral above it. Hence the rule for determining phyllotaxy: start from any leaf A and draw a

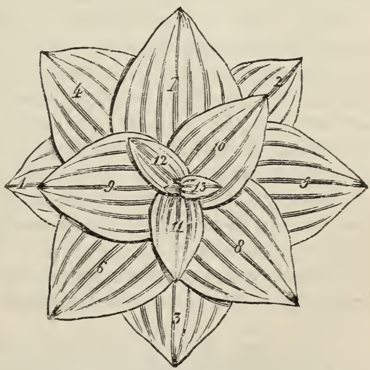


FIG. 2. $\frac{3}{8}$ PHYLLOTAXY.

spiral round the stem, passing by the nearest way through all consecutive leaves, to the leaf B exactly above A; then the number of leaves from A to B is the denominator, the number of turns of the spiral the numerator, of the fraction representing the phyllotaxy.

In Gramineae the phyllotaxy is $\frac{1}{2}$, *i.e.* leaves alternately on opposite sides of the stem, in Cyperaceae $\frac{1}{3}$. Nearly all other actual arrangements are terms of the continued fraction starting from $\frac{1}{2}$, $\frac{1}{3}$. If we add the numerators together to make a new numerator, and treat the denominators in the same way, we get the next arrangement $\frac{2}{5}$. This with $\frac{1}{3}$ gives $\frac{3}{8}$, and then $\frac{5}{13}$ and so on. It is rare to find a stem that shows the phyllotaxy very clearly; usually in the course of growth more or less twisting occurs (cf. Pandanaceae). The benefit of the phyllotaxy is that the leaves are spread out to occupy the available space to advantage; the larger the number of ranks the better this is effected, and the less shading of the leaves by one another there is[1].

The spreading out of the leaves is further assisted by the formation of *petioles* or leaf-stalks which carry the blades away from the stem and thus increase the space available. The stalk also enables the leaf to move more readily in the direction of the wind, so that the risk of tearing is lessened. A large leaf is never without a petiole, although small ones are commonly stalkless or *sessile*.

An examination of a branch, say of a Horse-chestnut (Aesculus), from above shows that the leaves, owing to the various lengths of stalk and other points, are arranged so that there is but little shading of one another, and hardly any space unoccupied. They form what has been termed a *leaf-mosaic*. Such mosaics are common in plants of our climate[2]. In dry climates (see Xerophytes, Chap. III.) the case is often different.

Phyllotaxies of these types give shoots of radial symmetry (p. 31); there are also bilateral arrangements, especially

[1] Asa Gray, *Structural Botany*; Goebel, *Organography of Plants*, p. 74 (mechanical theory); Sachs, *History of Botany*, Bk. I. Chap. IV.; Schumann, *Morphologische Studien*; De Vries in Prings. Jahrb. f. wiss. Bot. XXIII.

[2] Kerner, *Natural History of Plants*, I.; Lubbock, *Flowers, Fruits, and Leaves*.

upon horizontal shoots, which would obviously be inconvenienced by strict adhesion to the radial arrangement suited to the erect shoot. Sometimes the dorsiventrality is attained by the twisting of the leaf-stalks from the positions in which they arose, but more commonly there is a more or less two-ranked (*distichous*) phyllotaxy, the leaves arising upon the sides of the axis, and merely having to twist at their bases to place themselves horizontally. A further consequence of this is that the axillary branches also stand much in one plane. Good examples may be seen in the yew (Taxus), lime (Tilia), Betulaceae, Abies, Pinus, Ulmus, Anona, &c. In branches thus obliquely placed, a phenomenon termed *anisophylly* may often be observed. The leaves borne on the under side of the branch are larger than those on the upper, while the lateral leaves are intermediate in this respect. The difference is especially well seen in plants with opposite leaves. The phenomenon is largely dependent on external stimuli—gravity, light, &c.—but is hereditary or *habitual* in a number of plants, *e.g.* Centradenia, many Melastomaceae, Strobilanthes, Columnea, Tabernaemontana, Gardenia, Philadelphus, Salvia, Sambucus, Ligustrum, &c.[1]

In other plants, again, alterations of phyllotaxy occur for which no explanation can at present be given; *e.g.* in Solanaceae, Thelygonum, Quisqualis, Eucalyptus, Baptisia, &c.

The Leaf in most cases is a thin green expanded organ borne on the stem, and performing the great functions of assimilation and transpiration, together with respiration and more or less storage of materials. Details as to internal structure must be sought elsewhere; here it will suffice to say that the interior is usually made up of a spongy mass of green cells (the *mesophyll*), with *intercellular* air-spaces between them. These communicate with the outside air through minute openings (*stomata*) in the outer covering layer of cells or *epidermis*. The passage of gases for assimilation and respiration is through the stomata, whereas water also evaporates through the epidermis, the outer walls of which are usually covered by a waxy or corky layer, the *cuticle*. The cuticle is more or less resistent to the passage of

[1] Wiesner, *Anisomorphie d. Pfl.*, Sitzb. k. Akad. Wien, CI. 1892; *Stud. ü. d. Anisophyllie tropischer Gewächse*, l.c. CIII. 1894; Goebel, *Organography of Plants*, p. 65.

water, thus preventing excessive evaporation from the cells. Usually the cuticle is thicker, and the stomata fewer on the upper side of the leaf, while the cells of the upper mesophyll usually stand with their long axes vertical, forming a *palisade tissue*; this is most marked in leaves exposed to sunshine.

In the leaf the one or few vascular bundles that enter it from the stem commonly branch out a great deal, forming the *veins* or *nerves*. These, as may be seen in a skeletonised leaf picked up in winter, branch and rejoin (*anastomose*) repeatedly, thus forming a fine network all over the leaf. In the meshes of the network the final endings of the bundles may be seen as little blind branches. These run among the green cells and consist even at their smallest of a xylem and a phloem portion; the former supplies water to the assimilating cells, the latter carries away the products of assimilation to other parts of the plant. Except in the finer ramifications they are usually accompanied by a certain number of *fibres* whose function is primarily mechanical, the bundles being rendered elastic and comparatively rigid by their presence, so that the thin and delicate green parts of the leaf are stretched out smoothly and are less liable to injury by tearing.

The structure of a leaf is admirably suited to the performance of the great functions of assimilation and transpiration, the maximum of cell-surface being exposed to the air with the minimum of waste or of mutual interference of parts. Such, or something like it, is the structure of most leaves growing in sunny places with a plentiful supply of water from the roots. In very dry climates the transpiration would be too great for the water supply and the structure has to be modified to suit the new conditions (see Xerophytes, Chap. III.). Similar considerations explain the other modifications of structure found in water-plants, &c.

Storage of reserve-materials is only performed to a slight extent by such a leaf; the rapidity of assimilation during the day causes a temporary excess of the products, which are stored in the cells till night, when they are carried away. In many plants the systematic storage, for long periods, of large quantities of stuff, is undertaken by the leaves, which exhibit a more or less *fleshy* or *succulent* character (see Chap. III., Herbs, Xerophytes, &c.).

The access of air to the leaf-cells for assimilation favours respiration also, and as far as the influence of function upon structure is concerned we may neglect respiration.

The ordinary leaf described above has an upper or *ventral* and a lower or *dorsal* surface; the internal structure differs on the two surfaces, and such a leaf is termed *dorsiventral*. It reacts to gravity in a slight degree but is chiefly sensitive to light, and tends to take up during its growth a definite position with regard to the incident light (the *fixed light position*); in temperate climates this is usually at right angles to the brightest diffused light, *i.e.* approximately horizontal. Many leaves exhibit symmetrical internal structure, and stomata equally on either side, and place their *edges* to the light, *e.g.* Iris, Narthecium, Eucalyptus, etc.; such leaves are termed *isobilateral;* they may develope in this position or attain it by twisting. Physiologically, the *phyllodes* of Acacia (*q.v.*), &c. come under this head. In some species of Juncus, Allium, &c., the leaf is circular in section, with the tissues evenly distributed all round; it stands erect, and is termed a *centric* leaf. The isobilateral and centric types of leaf offer less surface to radiation and hence are less liable to excessive transpiration by day or excessive cooling at night. Many leaves obtain these advantages by movement, however, and yet retain the chief value of dorsiventral structure, viz. the great amount of assimilation due to the extent of surface exposed to light. Most Leguminosae execute *sleep-movements* with their leaves at night; the blades (in various ways in different plants) move so as to place their edges instead of their surfaces upwards. Oxalis is also a good example and there are countless others (see Darwin's *Movements of Plants*). In the tropics many leaves execute similar movements in the heat of the day, so that the light shall strike their surfaces obliquely, and thus not cause excessive decomposition of chlorophyll. The hanging of young leaves and shoots (see Chap. III.) is a similar phenomenon. We may also mention the 'compass-plants' Lactuca and Silphium. An exaggeration of the ordinary sleep-movements (which are regulated by the stimuli of light and temperature) is seen in Mimosa, Biophytum, Neptunia, &c., whose leaves take up the sleep position on being touched. *Desmodium gyrans* exhibits spontaneous movement without any apparent stimulus at all. The movements in all these cases take place by means of more or less swollen joints or *pulvini*. The pulvinus is chiefly composed of parenchymatous tissue, and the cells on one side gradually (or suddenly in Mimosa, etc.) lose their turgidity under the influence of the stimulus, while those on the other side retain theirs; the result is a bending of the joint. When the flaccid cells regain their water the joint straightens once more.

The external form of leaves presents extraordinary varieties in different groups of plants, even in nearly related forms, and we are at present almost ignorant of the factors determining it. The leaf commonly shows a distinction into the *leaf-base* or portion abutting on the stem, the *leaf-stalk* or *petiole*, and the *blade* or *lamina ;* attached to the base are often found a pair of *stipules*, one on either side, *e.g.* in the rose.

Even on the same plant the form is not always the same ; polymorphism (p. 29), here often called *heterophylly*, is frequent. Often, as in Hedera and other climbers, water-plants, epiphytes, insectivorous plants, Dischidia, &c. (see Chap. III. and Pt. II.) it bears some relation to differences in function, but in other cases, *e.g.* Capsella, Liriodendron, Bryophyllum, we cannot at present explain it.

Many peculiarities of leaf-form are bound up with the necessity for reduction of transpiration in certain climates, soils, or positions (see Chap. III., Xerophytes, Epiphytes, Shore-plants, Alpine plants) ; others with the acquisition by the plant of a climbing habit or a water-habit. Others occur in Insectivorous and Myrmecophilous plants, &c. Others are connected with the storage of reserves for hibernation or for vegetative reproduction, as in bulbs, &c., or with the protection of delicate parts as in winter buds, where the *scales* so commonly seen on the outside are leaves which have abandoned their normal functions and normal structure to take over the function of protection and with it a suitable structure. Scale-leaves occur in other positions and may be mere functionless relics or vestigial organs (p. 31), *e.g.* on many plants whose stems have taken over the usual leaf-functions, or in saprophytes or parasites where the changed mode of nutrition deprives the leaves of their value as organs of assimilation.

The acuminate apex so common in tropical leaves is apparently an arrangement for rapid drying (*cf.* Ficus, and Chap. III.). In many plants, *e.g.* Rutaceae, Guttiferae, the leaves show pellucid dots when held up to the light ; these are oil cavities in the tissue. Curious and often unexplained features are the holes in the leaves of Monstera and Aponogeton, the pockets of Xanthosoma, the blades in Codiaeum, the grooved petioles of Fraxinus.

Like the leaf itself the stipules also show great variety of form ; in *Lathyrus Aphaca* they do the assimilating work, whilst the rest of the leaf is transformed into a tendril, and in Azara, Viola, Rubiaceae, &c. they do a great deal of assimilation. Or they may be scaly and aid in bud-protection (Magnolia), or be represented by tendrils (Smilax), thorns (Acacia, Paliurus, &c.), hairs (Anacampseros), and so on.

Descriptive Terms. The student should practise describing leafy shoots until expert in handling the terminology, but there is no need to commit the terms to memory. At first he should describe in detail in the order given below, but afterwards he should try to render his descriptions short and pithy without sacrifice of essentials; this of course can only be well done by comparison with related forms to see what points are common to all.

Leaves as to phyllotaxy (above) may be *radical*, or on the subaerial stem (*cauline*); *whorled* (*verticillate*), *opposite* (and then *decussate* if each pair is at right angles to the next, *connate* if the two are concrescent as in Lonicera, *anisophyllous* if unequal in size or shape), or *alternate* (the phyllotaxy fraction may be given, or the number of ranks described by the terms *di-*, *tri-stichous*, &c.). With regard to its *insertion* or mode of union with the stem the leaf may be *petiolate* or *sessile* (*i.e.* with or without stalk respectively; the petiole is described like a stem), *auricled* (with two lobes of the blade overlapping the stem), *amplexicaul* (the lobes clasping the stem), *sheathing* (as in Grasses, the leaf-base forming a tube round the stem), *perfoliate* (the leaf united round the stem, as in Bupleurum), *decurrent* (continued by a wing on the stem, as in thistles), &c. It may bear a *ligule* or scale at the upper end of the leaf-base or sheath, as in Grasses. It may be *stipulate* or *exstipulate* (with or without stipules respectively); the shape, &c. of the stipules is described as if they were leaves, and they may be free or *adnate* (F in fig. 3; concrescent with the leaf-base or petiole, as in rose), united to other stipules, *inter-* or *intra-petiolar*, branched, &c. (see Rubiaceae), *ochreate* (sheathing, as in Polygonaceae), or modified in various ways (above). The *venation* (arrangement of the veins) may be *pinnate* or *palmate*; in the former case there is a *midrib* with lateral veins branching from it, in the latter several equal veins spread out in the leaf like the ribs of a fan, from one point. The further ramification of the veins is described by the terms *net-veined* (irregular meshwork, as in most Dicotyledons), *parallel-veined* (meshes more or less rectangular, as in most Monocotyledons), *fork-veined* (veins forking into two, as in Ferns).

Leaves are divided into *simple* and *compound*, according as the stalk bears one or several separate *leaflets*. In the latter case the leaflet is described as if it were a leaf, and the common stalk is often called the *rachis*. If the leaflets spring from the sides of the rachis, as in the pea, the leaf is *pinnate* (F), if all from one point *palmate* (E). If the leaflets of a pinnate leaf, as in many Acacias, are again pinnately compound, the leaf is *bipinnate*. A leaf with 3 leaflets (as in clover) is *ternate* or *tri-foliolate*, with 3 ternate leaflets *biternate*. Pinnate leaves may be *equally* (*pari-*) *pinnate* (with an even number of leaflets), *unequally* (*impari-*) *pinnate* (with an odd leaflet at the end), or *interruptedly pinnate* (large and small leaflets alternately as in many Rosaceae). A palmate leaf with 5 or 7 leaflets is often called *digitate*. The leaflet may have stipule-like organs, or *stipels* (adjective *stipellate*).

The leaf may be *dorsiventral*, *isobilateral*, or *centric*, or replaced by a *phyllode*, *scale*, *pitcher*, or other organ (see above).

The shape of the leaf-blade or leaflet itself, if simple, or the outline of a compound leaf, may be *needle-shaped* or *acicular* as in Pinus, *subulate* or awl-shaped, *tubular* as in onion, *linear* (long and narrow as in Grasses), *lanceolate* (about 3 times as long as broad, tapering gradually towards the tip; A in fig.), *ovate* (about twice as long as broad, and tapering towards the tip; B), *cordate* (similar, but heart-shaped at the base; C), *elliptical* (tapering equally to base and tip, and somewhat narrow), *oval* (do. but wider), *oblong* (sides parallel for some distance, the ends tapering rapidly; F), *reniform* (kidney-shaped), *orbicular* (circular in outline; if the petiole is inserted at the middle of the blade, as in Tropaeolum, this leaf is termed *peltate*), *hastate* (with two pointed lobes sticking out horizontally at the base), *sagittate* (two lobes projecting towards the stem), *spatulate* (spoon-shaped, as in daisy), &c. If a leaf be of lanceolate shape but the gentle tapering be towards the base, it is called *oblanceolate* (E), and so also leaves may be *obovate* or *obcordate*. If wedge-shaped, tapering to the base, it is *cuneate*. The leaf may be *oblique* or *asymmetrical* (F), when the midrib divides it into unequal halves, as in Begonia.

The leaf (or leaflet) may be *entire*, *i.e.* without notches in the margin (A), or *incised*; the margin may also be fringed or *fimbriate*,

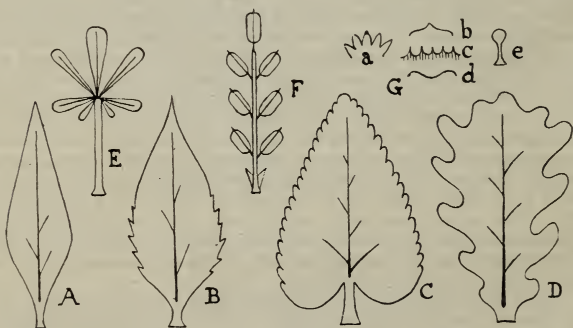


FIG. 3. FORMS OF LEAVES. A, subsessile, exstipulate, lanceolate with cuneate base, entire, acute. B, sessile, exstipulate, ovate, serrate below, entire above, acuminate. C, petiolate, exstipulate, cordate, crenate, obtuse. D, sessile, exstipulate, somewhat obovate, pinnatifid sinuate, obtuse. E, petiolate, exstipulate, palmate (digitate), with obtuse oblanceolate leaflets. F, impari-pinnate with triangular adnate stipules; leaflets shortly stalked, oblong, apiculate, the laterals oblique. G, *a*, plicate leaf in cross section, *b*, mucronate apex, *c*, dentate spiny margin, *d*, retuse apex, *e*, a common form of glandular hair.

cartilaginous, *membranous*, wavy or *undulate* (as in holly), curled or *crisped* (as in sea-kale), *spiny* (G*c*), *glandular* (with sticky hairs or glands; G*e*), *ciliate* (with fine projecting hairs), &c. If the margin has small teeth pointing forwards, it is *serrate* (B), if pointing outwards, *dentate* (G*c*); if the teeth are rounded but the notches sharp, the margin is *crenate* (C), if both teeth and notches are rounded, it is *sinuate* (D). If the depth of the divisions is equal to ¼ the distance from midrib to margin, *i.e.* if the incisions are conspicuous in proportion to the size of the blade, other terms come into use. If the notching is from ¼ to ½ the depth, the leaf is *-fid* (D), if ½ to ¾, *-partite*, if over ¾, *-sect*. Prefixes of *pinnati-* or *palmati-* are always used before these terms to express the particular form of notching, which depends upon the venation. The portions into which the leaf is thus divided are termed *lobes* or *segments*. Special terms are sometimes employed for such leaves as mustard (*lyrate*, the end lobe very large), dandelion (*runcinate*, the lobes pointing backwards), hellebore (*pedate*), &c.

The apex of the leaf may be *acute* (pointed; A), *obtuse* (blunt; C), *acuminate* (tapering in hollow curves to a long fine point; B), *emarginate* (notched), *retuse* (broadly notched; G*d*), *mucronate* (with a large stiff point on a nearly straight edge; G*b*), *apiculate* (do. with small point; F), *truncate* or *praemorse* (with broad, straight end, as if bitten off), *cirrhose* (tendrilled), &c.

The surface of the leaf, as of other parts, may be *glabrous* (without hairs), *pilose* (soft, scattered hairs), *downy* or *pubescent* (fine, soft hairs), *hairy* (coarser hairs), *hispid* (rough, bristly hairs), *tomentose* (with a cottony felt of hairs), *woolly*, *glandular-hairy*; *scabrous* (rough), *smooth*, *prickly*, *glaucous* (with blueish waxy gloss), *reticulate* (netted), *rugose* (ridged or wrinkled), *squarrose* (roughly scurfy), &c. Hairs may be *spreading* or *appressed* (flattened down), *simple* (unbranched), *glandular* (G*e*), *bifid*, *stellate* (like a starfish), *squamate* (scaly), &c.; prickles may be straight or curved, bent backwards (*retrorse*), &c. The leaf may be *dotted* with oil-glands, or *variegated* in colour, green, red, &c.; frequently occurring shades are *fulvous* (tawny), *rubiginose* (rust-coloured), &c. The texture may be *thin* or *herbaceous*, *coriaceous* (leathery), *succulent* or *fleshy*, *membranous* or *scarious* (thin, dry, not green, and flexible or stiff respectively), &c.

Leaves may further be *evergreen* or *deciducus* (falling in winter); in the latter case they may be *articulate* (cut off by a special absciss layer and falling early in winter), or *non-articulate* (hanging on to the stem, though dead, for an indefinite period, as in beech hedges, oak, &c.). The *vernation*, or folding of the leaves in the bud, is described like the aestivation of flower-buds (q.v.); the following terms are also used to describe the folding of the individual leaf, *conduplicate* (folded lengthwise as in oak), *plicate* (folded several times; G*a*), *involute* (margins rolled inwards), *revolute* (outwards), *reclinate* (apex bent down to base), *convolute* (leaf rolled spirally, as in Musa); conduplicate leaves overlapping younger ones thus $< < > >$, as in Iris, are called *equitant*.

When a character is not accurately described by one of the terms given, but is rather half-way beween two, both are used; thus a leaf may be linear-lanceolate or ovate-cordate. *Sub-*, meaning 'nearly,' is often used as a prefix to adjectives, *e.g.* subsessile, subacute. As an example of the use of these technical terms, we quote from Lindley the descriptions of two leaves :

Lilac: leaves opposite, exstipulate, roundish-cordate, very acute, thin, smooth, rather longer than the linear channelled petiole.

Garden Strawberry: leaves all radical, ternate, dark-green, somewhat shining, very coarsely serrated ; with strong parallel oblique veins, silky beneath ; leaflets nearly sessile, roundish oblong, entire towards the base, shorter than the semi-cylindrical hairy petioles ; stipules membranous, lanceolate, acuminate, half adnate.

Reproductive Organs.

The chief feature in the life-history of a plant is its reproduction, and it should be borne in mind that the preservation of the individual is of less importance than the preservation of the species. It is customary to distinguish between *vegetative* and *true* methods of reproduction. The former is the detachment of portions of the vegetative system—specialised for the purpose or not—which may grow into new plants without any further reproductive phenomena. 'True' reproduction, on the other hand, is propagation by special *cells* set apart for the purpose. These may be able to form new organisms without any sexual process, or they may require, as a preliminary to further growth, to fuse together (or portions of them) in pairs, male and female. In the first case we speak of *asexual* reproductive cells, or *spores*, in the second of *sexual* reproductive cells, or *gametes*, which by their union produce a new cell, the *zygote*, capable of further development into a new individual. The spores are contained in little capsules or *sporangia*, seen in typical forms on the back of a fern-leaf, or in the pollen-sac of a flower (fig. 6). The leaves on which they are borne are termed the *sporophylls*, and in this connection the plant bearing them is called the *sporophyte* or asexual plant. The sporangia often form groups called *sori*.

The spores may be of one kind or of two. In the former case (most Filicineae, Equisetum, Lycopodineae, except Selaginella and Isoetes) the plant is *homo-* or *isosporous*, in the latter (all other Pteridophyta and all Spermaphyta) *heterosporous*, with small and numerous *microspores* in *microsporangia* on *microsporophylls*, and fewer larger *macro-* or *megaspores* in *megasporangia* on *megasporophylls.* Only rarely do both kinds occur on one leaf, *e.g.* in Marsiliaceae.

In the ferns proper the sporophylls are not usually differentiated from the foliage-leaves; the same leaf usually both assimilates and bears the sporangia. In other Pteridophyta there is a differentiation of the reproductive part of the shoot (*inflorescence* or *strobilus*) from the rest, and the same is the case in the Spermaphyta. In Equisetum and in Lycopodium there is a *cone* of sporophylls, all of one kind; in Selaginella the cone consists of micro- and mega-sporophylls. The same is the case in the Gymnosperms and Angiosperms, *stamens* and *carpels* corresponding to micro- and mega-sporophylls, *pollen-sacs* and *ovules* to micro- and mega-sporangia.

There is good reason for believing that the structural separation of the reproductive and vegetative functions took place at least as early as the separation of the vegetative functions from one another; hence it is evident that we must be careful in comparing the organs of reproduction with the vegetative organs. We have no right to say, for example, that a sporophyll is a modified vegetative leaf; perhaps we should be nearer the truth if we said that a vegetative leaf was a modified sporophyll, for the sporophyte was probably reproductive before it was vegetative. It is convenient and justifiable to speak of the sporophylls as the leaves of the reproductive shoot, as their mode of arrangement, development, &c., correspond closely with those of the leaves of the vegetative shoot, but we must beware of assuming that the structural phenomena of the one shoot must necessarily have their counterparts in the other.

The spores of ferns and other Pteridophyta are shed upon the ground and there germinate, giving rise to little sexual plants, usually green, termed *prothalli*, entirely different in habit and structure from the asexual leafy plants. On these the male and female cells or gametes, called *spermatozoids* (*antherozoids*) and *ova* respectively, are borne in receptacles called *antheridia* and *archegonia*. The prothallus in this connection is called the *gametophyte*; in homosporous forms (except Equisetum) it usually bears both sexes, while in Equisetum and the heterosporous forms there are male and female prothalli.

The spermatozoids escape from the antheridium when ripe and swim to the archegonia (chemotropism or chemotaxis; p. 36); one of them unites with the ovum in an archegonium, the process being termed *fertilisation.* The resulting cell or zygote soon germinates and grows into a new leafy asexual plant. It is at first attached to the prothallus by an organ termed the *foot*, until it can feed itself. The life-history may be graphically represented thus (fern):

Leafy Plant or Sporophyte → Sporophylls → Sporangia → Spores
↑ ↓
Zygote ← { Spermatozoid ← Antheridia / Ovum ← Archegonia } Prothallus or Gametophyte.

It will be seen that there is an *Alternation of Generations*, sexual and asexual. This is a general feature of all the plants with which we have to deal, but in the Spermaphyta the gametophyte stage is much reduced and is no longer on the ground. The megaspore germinates in the ovule or megasporangium; the microspore or pollen-grain is carried to its neighbourhood by wind, insects, or otherwise. This preliminary operation is called *pollination*; the microspore germinates, and gives rise to a spermatozoid (Cycadaceae &c.) or to a tube (*pollen-tube*) which burrows to the ovum.

For further details of these phenomena see articles Pteridophyta, Filicineae, Gymnospermae, Angiospermae, Chalazogamae, &c.

Cross- and Self-Fertilisation. If, of the ova of a plant A, some be fertilised by male cells of A, some by male cells of a different plant of the same kind, B, will there be any difference between the offspring of self-fertilisation (A × A) and that of cross-fertilisation (B × A)? The answer to this question is supplied by the experiments of Darwin, detailed in *Cross- and Self-Fertilisation of Plants.* In each species seeds obtained by self-fertilisation (AA), and by fertilisation with pollen from a distinct plant (BA), were planted in pairs, one of each kind, in pots, and thus brought into competition. When fully grown the heights and weights were measured, and also the number and weight of seed produced. AA were again self-fertilised, BA again crossed, and so on for a number of years. The results were surprising. Even in one generation the offspring of cross- were superior in height, weight and fertility to the offspring of self-fertilisation; only a few exceptions occurred. In the succeeding generations the result became more and more marked. We may thus conclude, not, as has been so often done, that self-fertilisation is necessarily or in itself harmful, but that in general the offspring of cross-fertilisation will vanquish that of self-fertilisation in the struggle for existence, if the two be brought into direct competition, other things being equal, and that in general cross-fertilisation is much to be preferred, though self-fertilisation is better than none.

The advantage due to crossing shown in Darwin's results is compounded of several factors, fertility of the parent plant, strength of constitution of the offspring, and fertility of the offspring. Besides the advantages thus measured, it is probable that an important gain is made in the increased variability of the offspring resulting from cross-fertilisation.

On the other hand as compared with self-fertilisation crossing has certain drawbacks. It is (1) much less easy to ensure fertilisation when the pollen has to come from a distinct plant, and (2) fertilisation tends to be delayed (a point of importance in the short summer of alpine and arctic regions, where seed must be ripened before winter).

The advantages of cross-fertilisation are often great, and frequently enormous, and as at the first glance they appear to be obtained at little or no cost, we are inclined to expect this method of propagation to prove almost universal, and in fact it is extremely common. Self-fertilisation, however, is certainly the rule in many plants, although as the flowers are open there is a remote chance of a cross; in a few cases, so far as we know, the flowers never open, and crossing is absolutely prevented.

An important conclusion easily drawn from the facts is that cross-fertilisation costs the plant a certain price. If self-fertilisation be the rule, there is no necessity for any further complexity of flower beyond the organs bearing pollen grains and ovules (*i.e.* stamens and carpels), except something to ensure that the pollen shall reach the stigma, and be protected from injury by rain, &c. No more pollen than is absolutely necessary for fertilisation need be produced. If, however, the flower is to be crossed, extra expenditure must be made. If the carrying agent for pollen be wind or water, a vast amount of pollen must be wasted; if it be insects, though there is less waste, there must be brightly coloured organs, scent, honey, &c., to attract them. Thus it is that the plant has to pay a certain price for its cross-fertilisation (this price being affected by many factors, as we shall afterwards see), and only when the gain resulting from crossing is greater than the price to be paid for it will cross-fertilisation prove an advantage to the plant[1].

The advantages of fertilisation seem to rest upon the fact of the two parents having grown under slightly different conditions of life. The effect of a cross between two separate flowers on a plant A is but little if any better than that of the purest self-fertilisation within one flower, and the good effect of a cross A × B is greater if A and B have been grown at a distance apart than if grown near together. This is expressed in Nägeli's law that "the consequences of fertilisation reach their optimum when a certain mean difference in the origin of the sexual cells is attained." Varieties are frequently even more fertile together than plants of the same form, but when we go further and cross different species the value of fertilisation decreases again, sterility becoming a more or less marked feature in such unions.

Pollination. In all the higher flowering plants there must be, before fertilisation can take place, a preliminary operation—*pollination*—consisting in the transport of the pollen-grains to the ovules (Gymnospermae) or to the carpels (Angiospermae): a few general principles of this subject call for consideration here, and details are given below[2].

The general *agents*, external to the flower, effecting pollination are wind, animals, and water. The flower may

[1] MacLeod in *Bot. Jaarboek*, Gent, v. 1893 (review by Willis in *Science-Progress*, Nov. 1895); Müller's *Fertilisation of Flowers*; Sach's *History of Botany*; F. Darwin in *Nature*, Oct., 1898, p. 630.

[2] And see Darwin's *Cross- and Self-Fertilisation*, *Fertilisation of Orchids*, *Forms of Flowers*; Müller, *Fertilisation of Flowers*, *Alpenblumen*; MacLeod in *Bot. Jaarb.* v. 1893 (Dutch); Knuth, *Handbuch der Blütenbiologie*, &c.

effect its own (self-) pollination without assistance from any of them, but is dependent upon their help for cross-pollination. Of existing flowers a small number are only cross-pollinated (if pollinated at all), having by mechanical or physiological means lost all power of self-pollination (*autogamy*). Others again are solely self-pollinated, having no arrangements for utilising in their service either wind or insects. The majority of flowers occupy an intermediate position between these two extremes; they have arrangements, more or less perfect, for obtaining cross-pollination by external agents, while at the same time they are not so constructed as to be unable to perform self-pollination.

There is reason for supposing the primeval angiospermous flowers to have been cross-pollinated. There are many purely self-pollinated flowers now existing, but it is more easy to explain their features on the supposition of their descent from cross-pollinated ancestry than to suppose them primitively autogamous. Most of the striking examples occur in families or even in genera most of whose members are cross-pollinated. There is a price to be paid for cross-pollination, and if the gain from the process should by any means become less than the cost, the plant may perhaps revert to self-pollination. It is easy to imagine cases in which this might occur. Suppose an insect-pollinated species, A, in a certain district and suppose a new and attractive flower, B, to arrive from another district and establish itself; this will draw off some of the visitors of A and perhaps upset the balance of gain and loss, causing the latter to exceed the former. We shall then perhaps find A tending in the direction of increased autogamy; the result will probably be the gradual reduction of those characters by which its visitors were attracted, and it may gradually almost entirely lose them.

Suppose, however, that the introduction of B merely reduced A's profit but did not destroy it, then we might imagine A increasing its expenditure, so to speak, upon attractive characters, so as if possible to regain its former predominance. This will perhaps only be possible in plants which have stores of reserve-materials to draw upon, *capitalists*, as they have been termed, in contrast to annuals, &c. which have no reserves (*proletarians*). The balance between gain and loss may be affected in many ways, owing to the exceedingly delicate adjustment of the inter-relationships of the life of plants and animals in any district. Darwin's example of the effect of cats upon clover (*Origin of Species*, p. 57) illustrates this. The introduction of cultivation and therefore of new forms of plants into a district may produce serious effects upon the general balance of life there, even in the parts of the district most removed from the cultivated area; *e.g.* a field of clover may draw off most of the bees from the wild flowers.

Some plants can risk more for cross-pollination than others; *e.g.* an annual plant must set seed well, and so we find most annuals fully capable of autogamy. Long-lived perennials on the other hand can afford to try mainly for cross-pollination, and may even become incapable of autogamy altogether. The factors which have produced the particular phenomena seen in the pollination of any given flower are very numerous, and the problem to be solved before we can fully explain the phenomena is of a most complex description. Account has to be taken of vegetative reproduction, amount of storage of material carried on by the plant, climate, competition with other plants and so on. On comparing the floral phenomena of the same plant in different countries, we find a remarkable amount of variety, and this is no doubt largely correlated with the variety in the general conditions of life, &c. In this connection it is of great interest to study the floral mechanisms and insect visitors of the different species of such genera as Epilobium, Phacelia, Geranium, Gentiana (see Pt. II. and Müller's *Fertilisation of Flowers*) or such families as Caryophyllaceae, where within a small circle of related forms every stage may be seen, from high types with complex mechanisms and cross-pollination down to low types with simple mechanisms and self-pollination.

The earliest flowers must have depended upon the wind for pollen transport, and were therefore *anemophilous* or *wind-fertilised* (better *wind-pollinated*). This mode of pollination is not economical; vast quantities of pollen must be produced to ensure that some shall reach the ovules. Comparatively few flowering plants retain the anemophilous condition of their ancestry, and these have mostly acquired other characters which increase the chance of successful pollination. There is much risk of damage to pollen from rain, for it is necessary to expose it to ensure its being carried away by wind. Sporangia as a rule only open in dry air, and thus the risk is lessened. The close packing of the sporophylls upon the axis also helps to keep water from reaching the pollen.

At a very early period, perhaps, the transition from wind-pollination to insect-pollination (*entomophily*) began, and from this period the evolution of most flowers went on hand in hand with that of insects, and is best studied in connection therewith. It is not difficult to imagine how the transition may have begun. Pollen is formed in great quantities in anemophilous flowers and is a very nutritious food. The earliest flying insects would only have very short lips, but finding the pollen freely exposed would be able to feed on it, and in this way might get into a regular habit of flower visiting. Pollen adhering to their bodies might thus be carried from flower to flower, and self-pollination also might occur.

Water-pollinated (*hydrophilous*) plants are few, and are all probably derived from land-plants (see Chap. III.).

The Inflorescence. In some of the older types of plants with which we have to deal, *e.g.* in the *cones* of some Lycopodineae, Equisetineae, and Gymnosperms, there is simply an axis bearing an indefinite number of sporophylls, of one or two kinds. This is a most primitive type of reproductive shoot, and we can perhaps hardly call it a flower, but it is no great stretch of a term to apply to it the name *inflorescence*, as we have already done. In the vast majority of cases, however, the reproductive shoot or inflorescence is differentiated into, or is composed of, or bears, a number of shoots of limited growth (p. 42) termed *flowers*. It may be that from each of the numerous cones of the primitive forms one flower was derived, and that the flowers tended to become aggregated together, or it may be that from each cone a number of flowers were derived (see Coniferae); we have at present no means of drawing a definite conclusion, but it would seem probable that the former view is nearer to the truth.

Very commonly a plant has only one inflorescence, but most often the reproductive shoots are several in number, divided by portions of the vegetative shoot.

The construction of the inflorescence depends chiefly on the mode of branching, whether monopodial or sympodial, but also on the varying rate of growth of its different parts, variation in symmetry, adnation, &c.

The flowers may be sessile or on stalks (*pedicels* of single flowers in a group, *peduncles* of groups of flowers or solitary flowers). Each flower arises, as a rule, in the axil of a leaf, which is termed its *bract*; and any leaves on the same axis as the flower itself, between it and its bract, are termed the *bracteoles* of the flower. The lowest bracteole is often termed α, the next above β, and so on (cf. floral diagrams). These terms merely express the relative positions of the parts; the same leaf may obviously be the bracteole of one flower and the bract of another. Bracts are absent in a few cases; *e.g.* most Cruciferae, many Umbelliferae and Compositae are *ebracteate*; the bracteoles also are frequently missing. In Dicotyledons there are usually two bracteoles, placed transversely (*i.e.* if the bract face S. they face E. and W.), in Monocotyledons commonly one, on the side opposite to the bract. In condensed inflorescences the bracts are often collected together into whorls or what look like them; such *involucres* may be seen on the heads of Compositae, &c., the umbels of many Umbelliferae, and so on. The term involucre is also given to a whorl of leaves below a single flower and upon the same axis, as in Anemone and its allies.

In general the bracts resemble the foliage-leaves but are usually smaller and more simple in construction. In some cases, *e.g.* Euphorbia sp., Salvia sp., Castilleja, Amherstia, Bougainvillea, they are brightly coloured, aiding in the attraction of insects to the flowers. They may also exhibit modification into thorns, &c., like foliage-leaves. In many Monocotyledons, *e.g.* Palms, Araceae, &c., there is a large leaf borne at the base of the inflorescence and on the same axis; this is termed the *spathe*, and usually encloses the whole inflorescence when young; the latter, if of the spike pattern, is then usually termed a *spadix*. The spathe is brightly coloured in many Araceae, *e.g.* Anthurium, Richardia.

The typical monopodial inflorescence is the *raceme*, in which the main shoot grows steadily onwards, bearing lateral branches in acropetal succession; each branch terminates in a flower. The oldest flowers are thus those furthest away from the apex of the main shoot, and the order of opening of the flowers is *centripetal.* This inflorescence is also frequently called *indefinite* or *indeterminate*, because the first axis does not, as a rule, end in a flower; exceptions occur however in Aconitum and other Ranunculaceae, &c. Good examples of the simple raceme occur in Ribes, Cruciferae, Berberis, Prunus sp., &c.

If instead of each branch bearing but a single flower, it bear another raceme, we get a compound raceme or *panicle*, as seen in oats and many other grasses; the terms applied to inflorescences are, however, very loosely used, and the name panicle is given to any inflorescence presenting this loosely branched appearance, whether the branching be racemose or cymose, or both. If in the simple raceme the flowers be imagined all sessile, we get the simple *spike*, as in Plantago. This also may be compounded; true compound spikes occur in wheat and other grasses, &c.; often, however, the secondary branching is cymose. In practice the name spike is given to all elongated inflorescences of sessile flowers, whatever the branching. A variety of the spike is the *catkin*, *amentum*, or pendulous spike, seen in hazel, oak, chestnut, &c. If we imagine the stalks of all the lateral flowers of a raceme to grow as fast as the main axis, we get a simple *corymb*, with all the flowers at one level, as in candytuft (Iberis) and other Cruciferae. The name is also given to all branched inflorescences whose flowers stand at about the same level. If we imagine the corymb to have its main axis 'condensed' so that all the stalks of the individual flowers spring from one point—its summit—we get the *umbel.* This is usually compound, as seen in Umbelliferae, and may be cymose (see below). Lastly, if the flowers of the umbel be imagined sessile, the summit of the stalk being enlarged into a *common receptacle* to bear them, we get the *head* or *capitulum*, as seen in Compositae; this too may be compound, as in Echinops, &c.

In the sympodial or *cymose* inflorescences, the general principle underlying their variety is that each branch, when formed, ends in a flower after bearing a few leaves (bracteoles), usually one or two in number. From the axils of these leaves the branching is continued. The term *definite* or *determinate* is often applied to inflorescences of this type, to indicate this peculiarity of the branching. The inflorescence (termed generally a *cyme*) is built up of a number of 'short shoots,' which frequently form a true straight sympodium (p. 42), especially in the older (fruiting) part of the inflorescence. If each successive branch bear upon itself one new branch only, the cyme is termed *monochasial*, if two, *dichasial*, if more, *pleiochasial.*

Typical dichasial cymes occur in Caryophyllaceae, Gentianaceae, &c. (A in figure); they are usually found with opposite leaves, but sometimes with alternate. From the axils of the bracteoles b_2 of the flower 1 spring shoots, each bearing two bracteoles (b_3) and a flower (2), and so on. Commonly, of the two shoots one is more strongly developed than the other, and the difference often becomes more strongly marked at each branching, and the cyme may thus even become monochasial in its later formed parts (by preference, as it is termed, of one or other bracteole). The figure represents all the shoots in one plane, but usually the plane of each successive pair of branches is at right angles to that of the preceding pair; in other words, the plane of the shoots 3, 3, 3, is at right angles to the plane of the paper.

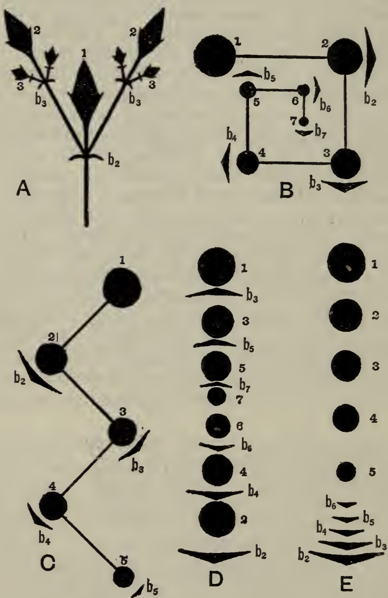


FIG. 4. DIAGRAMS OF CYMOSE INFLORESCENCES (partly after Eichler, but modified). A, dichasial cyme; B, bostryx; C, cincinnus; D, rhipidium; E, drepanium. The figures 1, 2, 3, &c. mark the flowers and their order of age (also indicated by the size of the circles); the letters b_2, b_3, &c. mark the bracts, in whose axils the flowers 2, 3, &c. respectively arise. A is a side view, all the shoots being represented in one plane; the rest are ground-plans.

Monochasial cymes are of four types, the ground-plans of which are represented in the figure. If each successive lateral branch fall upon the same side of the relatively main axis, we get the two cases represented by B and E; the former is termed a *bostryx* (Schraubel), and is found in Hemerocallis, Hypericum, &c.; the latter is termed a *drepanium* (Sichel), and occurs in Juncaceae, &c. If each successive lateral branch fall in turn on one side and on the other of the relatively main axis, we get the cases represented by C and D. The former is termed a *cincinnus* (Wickel); it occurs in Helianthemum, Boraginaceae, Hydrophyllaceae, Pentaphragma, Tradescantia, &c., and is coiled up in the bud like a crosier. The latter is similar but has all the flowers in one plane instead of two; it is termed a *rhipidium* (Fächel) and is found in Iris, &c.[1]

Most monochasial inflorescences straighten out more or less into sympodia, which have the appearance of racemes, but are distinguished by the fact that the apparent lateral branches of the raceme are not in the axils of the leaves, but usually opposite to these organs.

A considerable number of the flowering plants possess *mixed* inflorescences, in which some of the branchings are cymose, some racemose.

E.g. in Aesculus the primary branching is racemose, but the lateral shoots each form a cincinnus (this inflorescence is usually termed a panicle; see above). In Labiatae the primary branching is racemose, the lateral shoots are dichasial. Other examples are Betulaceae, Verbascum, Morina, Ceratostigma. In Statice the primary branching is racemose, but the lateral shoots are drepania. In Haemanthus and many other Amaryllidaceae the apparent umbel is really made up of 'condensed' bostryx-cymes. In Allium and others the 'condensation' is greater and cymose heads are formed. Some species of Juncus have heads of drepania, and so on. Many Umbelliferae have cymose heads or umbels, also Sparmannia, Armeria, Dipsaceae, &c. These inflorescences are distinguished from true heads, &c., by the fact that the order of opening of the flowers is not centripetal.

The simplicity of the morphology of the inflorescence is interfered with by adnation (p. 42) even more often than that of the vegetative shoot. Cf. Solanaceae, Samolus, Cuphea, Tilia, Erythrochiton, Chailletia, Spathicarpa, Spathiphyllum, &c.

Another peculiar case is the *reduction* of a complex inflorescence to a simple one by suppression (p. 31) of its

[1] The terms scorpioid cyme and helicoid cyme are avoided, on account of the hopeless confusion of their definitions in the various text-books. The student may familiarise himself with these forms of cymes by constructing models out of matches with sharpened lower ends (the head representing the flower).

flowers. Thus the umbels of Xanthosia and Chorizanthe, the dichasia of Mirabilis, the heads of Echinops, are each one-flowered; the female head of Xanthium two-flowered. In these cases comparison with the related forms, and the frequent possession of an involucre by the one flower, leaves no doubt as to the explanation. An immense number of plants have true *solitary* flowers, *i.e.* usually one flower in each leaf-axil, loosely arranged on the main axis. These *may* be reduced inflorescences, but in most cases, probably, are not so.

One of the most interesting cases of reduction is the cyathium of Euphorbia (*q.v.*), in which a whole inflorescence is reduced in such a way as to look like a single flower, whilst really composed of many individual flowers. This inflorescence has separate male and female flowers, arranged in a definite way with regard to one another; similar phenomena occur in many Moraceae (*e.g.* Brosimum), Begonia, Echinophora, Ficus, Cyclanthus, &c. All these have inflorescences of peculiar types; cf. Part II. for details; see also Urticaceae, Triumfetta, Spiranthes, Acroglochin, Rhus, &c.

One advantage, underlying the differentiation of the shoot into vegetative and reproductive parts, seems to be the formation of many spores near together on the shoot. In Cryptogams this is useful because the prothalli will tend to be nearer together upon the soil, thus favouring fertilisation. In flowering plants the microspores (pollen) have to be carried to the ovules or carpels, generally by the aid of wind or insects. The massing together of the flowers tends to free them from the vegetative leaves, which interfere with wind-transport by interposing obstacles, and with insect-transport by rendering the flowers less conspicuous. The more the flowers are massed together the more conspicuous do they become, the more quickly can they be visited by insects, and the smaller the size of the individual flower may be. The highest degree of perfection in this way is found in the Compositae (*q.v.*). Conspicuousness is often gained in other ways, *e.g.* by ray flowers, as in Compositae, &c., coloured bracts (see above), unilateral arrangement of the flowers (Digitalis, Mitella, Boraginaceae, &c.), and so on.

The Flower may be defined as a reproductive short shoot. It consists essentially of an axis (*receptacle*, *thalamus*, or *torus*) bearing sporophylls (*stamens* and *carpels*). These are the *essential organs*, and there are usually also some *accessory organs*, or non-spore-bearing leaves, forming a *perianth*, which is most often in two series, the outer leaves (*sepals*) forming a protective *calyx*, the inner (*petals*) a coloured *corolla*.

We shall deal with the morphology from a phylogenetic and ecological point of view, endeavouring to trace the gradual evolution and differentiation of the various parts in the light of the principle of the physiological division of labour. It is necessary to keep clearly in mind what has been said above about cross- and self-fertilisation and pollination. The primary object of the flower, to speak in a figurative manner, is to set seed with as much economy as possible. A saving of material in the flower may be applied to increasing the weight or number of the seeds. A great number of plants are adapted chiefly to cross-pollination and this introduces numerous complications into their morphology. Others again have, in the course of ages, become adapted to self-fertilisation, but previous adaptations for crossing may still remain in a more or less imperfect condition. Other important points are protection of the essential organs from the weather, economy of pollen and ovules, improvement of mechanisms for pollination, attraction of more and cleverer insects, exclusion of less desirable insects, and so on. All of these specialisations are reflected in floral morphology.

It is not altogether improbable that at a very early period the ancestors of the present flowering plants had simple cone-like flowers, each composed of an axis bearing micro- and mega-sporophylls. Such a flower is approximately represented by the cone of Selaginella, and by comparing with it the flowers of to-day in all their variety we can trace the corresponding organs throughout, and infer what new organs have arisen and what changes have occurred. Comparative study of floral structure shows that the seeming infinite variety can be largely brought under a few heads which apparently represent lines upon which evolution has progressed in connection with the specialisations outlined above. With these features we shall now deal in order, and afterwards with the special morphology of the floral organs, and their natural history.

Descriptive Terms and further details are given after each section of floral morphology dealt with. The beginner should work through each section with flowers in hand, dissecting, describing, and sketching; after he has had some practice in this work he should go on to describe the flower as a whole[1].

Segregation of Sporophylls or grouping of each kind by itself, is characteristic of nearly all existing flowers except Selaginella &c. and must have occurred very early in the evolution. The sporophylls may be all in the same *hermaphrodite*[2] or *bisexual* (☿) flower, or may be in separate *unisexual*[2] flowers, the microsporophylls or stamens in *male*[2] or *staminate* (♂), the megasporophylls or carpels in *female*[2] or *pistillate* (♀) flowers. In hermaphrodite flowers the carpels occupy the summit of the axis, and the stamens stand below them.

Unisexual flowers occur in a number of Phanerogams, but in all but the Gymnosperms, the catkinate families, and perhaps a few others, they are probably derived from hermaphrodite ancestors, as is indicated by the male flower usually possessing rudimentary carpels, the female rudimentary stamens. Examples occur in Sagittaria, Rhamnus, Begonia, Aucuba, Bryonia, Petasites, Tussilago, &c. Other "distributions of sex" are also found.

Descriptive Terms, &c. Plant with both stamens and carpels in one ☿ flower, *monoclinous*, in separate ♂ and ♀ flowers, *diclinous*; ♂ and ♀ flowers on the same plant, *monœcious*, on separate plants, *diœcious*. Other complications are *gynomonœcism* (☿ and ♀ on the same plant, as in some Labiatae, Compositae, &c.), *gynodiœcism* (☿ and ♀ on separate plants, as in Nepeta, Thymus, and other Labiatae, Plantago, many Caryophyllaceae, &c.), *andromonœcism* (☿ and ♂ on one plant, as in Veratrum), *androdiœcism* (☿ and ♂ on separate plants, as in Dryas), *triœcism* (☿, ♂, ♀, each on its own plant, as in Silene sp.), *polygamy* (☿, ♂, ♀, in various combinations on one or more plants, as in Rhus, Fraxinus, &c.). All these phenomena, except monœcism and diœcism

[1] The following works may be consulted with advantage: (*Morphological*) Goebel, *Organography of Plants*, *Entwicklungsgeschichte der Pflanzenorgane* (in Schenk's Handbuch der Botanik); Eichler, *Blüthendiagramme*; Schumann, *Morphologische Studien*, *Neue Untersuchungen über die Blütenanschluss*; Payer, *Organogénie de la Fleur*; Bower, *Studies in the Morphology of Spore-producing Members* (Phil. Trans., recent years); (*Ecological*) the books mentioned under Pollination on p. 58.

[2] These sex terms ought not to be applied to parts of the sporophyte, but are firmly established in botanical literature.

(and even then perhaps in the derived cases) are probably largely connected with nutrition and correlated variation, and their value to the plants possessing them is problematical[1].

Reduction in number of Sporophylls, and ***Arrangement of Floral Leaves in Whorls,*** are two widely spread features of the more highly evolved flowers. The aggregation of sporophylls to form flowers causes many spores to be formed near together; the advantages of this were pointed out on p. 66. As means of pollination improve in flowers, the number of sporophylls and sporangia need not be so great as in the more primitive forms, and in general we find it smallest in the most highly specialised flowers. Many of the lower types of flower now existing, *e.g.* in Ranunculaceae and other orders of the Ranales, have their sporophylls, and often their perianth-leaves, spirally arranged on the axis, but in most flowers they are in whorls and the axis is correspondingly shorter. The members of any whorl usually alternate with those of the next, but sometimes are opposite to them, or of different number.

The lower existing types of flowers have many stamens and carpels, the higher have generally two whorls of the former and one of the latter, and this whorl, too, is usually reduced in number. A very common case is for the outer whorls to be of 5 members each, the carpellary whorl of 3 members or even fewer. In the Sympetalae all but the lowest have only one whorl of stamens, and usually only two carpels, or even one. The number of ovules is commonly reduced also in the highest types of entomophilous flowers; the Compositae, for instance, show only one in each flower. In anemophilous flowers the number of ovules is usually small, perhaps because of difficulty in pollination. Other plants of high type, again, *e.g.* Orchids, find an advantage in numerous ovules (and compare Labiatae with Scrophulariaceae).

Descriptive Terms, &c. Flower with leaves all spirally arranged, *acyclic*, all in whorls, *cyclic*, part in spirals, part in whorls, *hemicyclic;* whorled, with the same number of organs in every whorl, *eucyclic* (the whorls, or flower, *isomerous*), with different numbers, *heterocyclic* (whorls, or flower, *hetero-* or *aniso-merous*, the whorls with fewer organs

[1] Willis, *On Gynodiœcism* &c. 3 papers in Proc. Camb. Phil. Soc., 1892–3.

oligomerous, with more members, *pleomerous*). Flower with 2, 3, 4, 5 whorls *di-*, *tri-*, *tetra-*, *penta-cyclic*; with 2, 3, 4, 5 members in each whorl *di-*, *tri-*, *tetra-*, *penta-merous*. The number of organs in each whorl is given if the flower is heteromerous; if over 10 and variable it is usually termed *indefinite*, *e.g.* stamens and carpels of Ranunculus. Members of one whorl are usually *alternate* to those of the next outer whorl, but may be *opposite* (*superposed*, *anteposed*) to them; this is usually described as 'Stamens antepetalous' and so on (see stamens, below, and diagrams of Caryophyllaceae, Primulaceae).

Concrescence (p. 30) of organs is a common and important phenomenon. When it takes place between similar organs, *e.g.* in the corolla of the Sympetalae, it is commonly termed *cohesion*, when between dissimilar organs, *e.g.* between stamens and petals, as in thyme or mint, *adhesion*. The latter rarely occurs without the former. Concrescence of sporophylls, especially of carpels, probably effects great economy in fertilisation, by making only one track for the pollen-tubes to all the ovules; in the perianth it often saves material and helps to narrow the entrance to the honey (see below).

Descriptive Terms. Perianth, calyx, corolla, stamens, carpels, of organs free from one another, *polyphyllous*, *polysepalous*, *polypetalous*, *polyandrous*, *apocarpous*; of concrescent ('coherent') organs, *gamophyllous*, *gamosepalous*, *gamo-* or *sym-petalous*, *monadelphous* (if all stamens concrescent; see below under stamens), *syncarpous*. Stamens concrescent with ('adherent to') carpels, corolla, calyx, perianth, *gynandrous*, *epipetalous*, *episepalous*, *epiphyllous*. The concrescent portion is termed the *tube*, the free part the *limb*; the latter is divided into *lobes*, *teeth*, or *segments*.

Multiplication of organs, or the presence of more than one in a place where comparison (p. 27) shows that there was probably only one in an ancestral form, is not infrequent. It is usually due to *branching* (*chorisis*, *dédoublement*), and is especially common in stamens, *e.g.* in some Myrtaceae (Calothamnus, &c.), Papaveraceae (Fumaria, &c.), Ricinus, Polygonaceae, Malvaceae, Cruciferae, Capparidaceae, Guttiferae, &c. It occurs in the carpels of Nolanaceae and many Malvaceae, &c.

Abortion and ***Suppression*** (p. 31) are also common. Reduction of number of sporophylls and oligomery of the carpels are mentioned above. Abortion is very common in stamens, small functionless *staminodes* being left, *e.g.* in Scrophularia; it also occurs in the petals of Aconitum, the carpels of male flowers (above), &c. Suppression of a whole whorl has probably occurred in the evolution of many flowers with only one whorl of stamens, in the petals of *apetalous* flowers, *e.g.* many Caryophyllaceae, in the perianth of such *naked* flowers as Achlys, and so on.

Change of Form of the Receptacle is a frequent case. In primitive flowers, and in many now existing, the axis is more or less elongated, with the carpels at the top or *superior*, and the other organs arranged below them or *hypogynous* (A in fig. 5). In Fragaria, Potentilla, &c. the receptacle in its development becomes flattened on the top by the more rapid growth of the sides, so that in section it has a kind of ▽ shape. In Acer, Ruta, and many other plants of the orders placed in Disciflorae by Bentham and Hooker (see Chap. II.) the flattening is above the calyx, so that a *disc* is formed in the base of the flower, bearing corolla, stamens and carpels. In Rosaceae, Crassulaceae, &c. (most of the Calyciflorae of Bentham and Hooker), however, the calyx also is borne on the edge of the flattened receptacle. Usually the growth of the sides goes on so far as to make the upper surface concave, so that a shallow or deep cup is formed, with the calyx springing from its margin (B in fig. 5). The texture of the cup is usually similar to that of the calyx, often to such an extent that it is impossible to point out by mere inspection of the outside where one ends and the other begins, and we may if we please regard the phenomenon as one of concrescence of the calyx, with the corolla and stamens also taking part. This is partially the older view expressed in the term "Calyciflorae." The corolla usually springs from the margin of the cup, and the stamens lower down in it. In these flowers, while the carpels or gynœceum are still superior, the other organs, springing around them, are termed *perigynous*, even if the tube of the flower be so deep that they spring above the carpels.

Epigyny is another line along which evolution seems to have proceeded. The genus Saxifraga may perhaps serve as an illustration. In it there are some species with almost hypogynous flowers; others have a more cup-like receptacle, but the carpels are united at the sides to the cup. Some show this phenomenon to a very slight extent, others to such a degree that only the styles remain free, the ovary being completely immersed in the hollow receptacle (C in fig. 5). Such an ovary is termed *inferior*, and the other parts of the flower are *epigynous*. It seems probable enough that

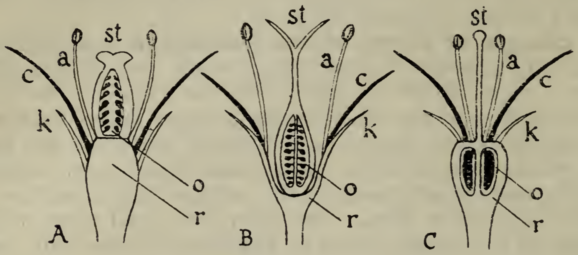


FIG. 5. DIAGRAMMATIC LONGITUDINAL SECTIONS OF FLOWERS, to show types of receptacle, ovary, stigma, &c. A, hypogynous flower with unilocular ovary, parietal placentation, and numerous ascending anatropous ovules with raphe downwards; stigma sessile, bilobed. B, perigynous flower with multi-locular ovary, axile placentation, and numerous horizontal anatropous ovules with raphe upwards; style with bifid stigma. C, epigynous flower with multi-locular ovary, apical placentation, and solitary pendulous anatropous ovules with ventral raphe; style long with capitate stigma. *r*, receptacle, *k*, calyx, *c*, corolla, *a*, stamens, *o*, ovary, *st*, stigma.

such a series of stages may have occurred in the original evolution of epigynous flowers; it is at any rate improbable that many were derived from perigynous flowers with any important depth of tube. Epigyny is found in Umbelliferae, Compositae, Rubiaceae, Iridaceae, Begoniaceae, and elsewhere.

Descriptive Terms, &c. Flowers, or perianth, calyx, corolla, stamens, may be *hypo-*, *peri-* or *epi-gynous* (above); the gynœceum *superior* or *inferior*. Perigynous flowers may be shallowly or deeply perigynous; in the latter case the *tube* is described as to length, texture, &c. There may be a *disc* in the flower (see above). Sometimes outgrowths (*effigurations*) of the receptacle are seen, *e.g.* in Passiflora, Capparidaceae, Orchidaceae, &c. Sometimes the receptacle elongates between the whorls of floral members, *e.g.* in Lychnis between calyx and corolla, in Passiflora and in many Capparidaceae between corolla and stamens, in Capparis between stamens and carpels. If the elongated portion bears the stamens it is termed an *androphore*, if only the carpels, a *gynophore*. Other receptacular outgrowths are seen in epigynous flowers, *e.g.* the wings on the inferior ovary of Begonia, the thorns (which sometimes bear flowers) on that of Tetragonia, the nectariferous disc of Umbelliferae, Compositae, &c., and so on.

Floral Symmetry is another feature that shows much variety in its evolution. In a good many flowers the number of members in each whorl is the same, and each member of any whorl is like every other member of the same whorl in size, shape, texture, &c. The symmetry is radial (p. 31) or *actinomorphic*, and the flower is *regular*, *e.g.* in the Ranunculaceae, Rosaceae (see diagrams in Part II.), Crassulaceae, Ericaceae, &c. It more frequently happens than not that the symmetry, perfect in the outer whorls, is disturbed by the fact of the gynœceum possessing too few carpels, as in most Sympetalae. Such flowers, however, are generally termed actinomorphic also. But if one or more members be missing from any of the outer whorls, or if in any whorl all the members are not exactly alike, then the flower is *irregular*. If it can be divided symmetrically in any plane, it is *zygomorphic* (see floral diagrams of Papaveraceae, Labiatae, Scrophulariaceae, &c.); if it cannot be so divided it is *asymmetrical* as in Valerianaceae.

The flower usually stands in the axil of a bract and as a rule the same side of each flower on any plant faces the bract. The side facing the bract is *anterior*, that facing away from it, *i.e.* towards the original stem, is *posterior*. The upper side of a floral leaf, as of a vegetative leaf, is *ventral*, the lower *dorsal*.

A great many families, *e.g.* Ranunculaceae, contain both regular and irregular flowers, whilst others, *e.g.* Labiatae, contain only the latter. The change from regularity to irregularity is then one which has begun independently in many branches of the phanerogamic tree (p. 29). Of the determining and active causes we know little, but we may easily see the advantages of the change. Irregular flowers usually stand more or less horizontally, whereas regular ones are most often, perhaps, erect. A flower that stands horizontally will obviously protect its pollen better, at least in those stamens that are uppermost. Further, the only convenient track for the entering insect is by the lower side. We can easily imagine the evolution of such a flower into a zygomorphic one. The lower stamens and the style might bend over to come under the upper side of the flower, and this might develope into a protective hood, whilst the lower half of the flower (usually only the corolla) might enlarge into a conspicuous lower lip, forming the landing-place for insects, as in most Labiatae and allied orders, Orchidaceae, &c. If the lower half of the corolla, on the other hand, assumed the protective duties, we should get such a case as seen in the Leguminosae. This fact, that the flower has now only one track to the honey instead of many, is probably one of the chief advantages of zygomorphism, as it enables the anthers and stigmas to be kept in the one place only and thus favours economy of pollen, &c.

The two-lipped condition, however, is not the only form of irregularity. Very often one petal differs from the rest in shape, *e.g.* the lower petal of Viola is drawn out into a spur in which the honey is protected from short-lipped insects. Similar phenomena occur in Delphinium, many Orchids (Angraecum is the most remarkable), and many Sympetalae, *e.g.* Centranthus, Linaria. In the irregular outer flowers of the condensed inflorescences of many Cruciferae, Umbelliferae, Compositae, Dipsaceae, &c., the advantage seems to lie chiefly in greater conspicuousness.

Gravity and other causes seem to have had a good deal to do with the determination of zygomorphism, and it must not be regarded without further proof as entirely an adaptation to insect-pollination. It occurs in the wind-pollinated Podostemaceae[1].

Descriptive Terms, &c. Flowers may be *regular* or *irregular*, *actinomorphic*, *zygomorphic*, or *asymmetrical* (see above). In zygomorphic flowers the plane of symmetry is usually the antero-posterior plane. Transverse zygomorphism occurs in some Papaveraceae (*q.v.*), Haemodoraceae, Anigozanthos, &c., diagonal in Solanaceae, &c., right- and left-handed in Exacum, Saintpaulia, Cassia, &c. Twisting of the stalk of the flower sometimes alters the plane of the symmetry, as in Lobelia, Orchidaceae, Fumaria, Impatiens, &c. The terminal flower of an inflorescence has sometimes a different symmetry from the laterals, *e.g.* in Ruta, Acer, Adoxa, Acalypha, &c. (cf. also the peloria of Linaria). In Ariopsis, Cyclanthus, Morinda, Lonicera, &c. more or less union of different flowers occurs. Mention may also be made of the *polymorphism* of the flowers of some Orchids, *e.g.* Catasetum.

Irregularity is most common in the perianth, and the terms used are given below.

The Flower Bud. In the young bud the floral organs

[1] Goebel, *Organography of Plants*; Vöchting in Pringsh. Jahrb. f. wiss. Bot. XVII, 1886; Robertson in Bot. Gaz. 1888; Willis (dorsiventrality of Podostemaceae) in Ann. Perad. I, 1902, pp. 426, 434.

are closely packed in a definite way which is always the same for the same flower and often for a whole family; so that this *aestivation* (*cf.* vernation, p. 41) is a character of importance in classification. Only the perianth is considered, as a rule, and the aestivation is easily seen in a cross section (*cf.* floral diagrams in Part II).

Descriptive Terms, &c. Leaves or segments not even meeting at edges, the aestivation is *open* (corolla of Cruciferae), touching but not overlapping, *valvate* (corolla of Compositae), overlapping, *imbricate* (calyx of Leguminosae). Special cases of imbricate are *convolute* or *contorted* (each leaf overlapping with the same right or left edge, so that the corolla looks twisted, as in Malva, Gentiana, &c.) and *quincuncial* (two leaves overlapping with both edges, two underlapping with both, one over- and under-lapping, as in calyx of Caryophyllaceae). Each leaf overlapping the one posterior to it, *ascending* (calyx of Vicia in Leguminosae), anterior to it, *descending* (corolla of Vicia). Leaf margins turned inwards, *induplicate* (corolla of many Compositae), outwards, *reduplicate.* Leaves rolled up inwards like watch springs, *circinate* (petals of Hamamelidaceae).

Most commonly all the flowers on a plant show the same aestivation in detail, or are *homodromous*, as opposed to the *heterodromous* flowers of Marantaceae, Exacum, Saintpaulia &c., in which a right-hand flower is arranged the opposite way to a left-hand flower, so that a particular organ twisted to the right in one is twisted to the left in the other.

The Perianth, or outer covering of the flower, composed of non-reproductive leaves, is an organ that dates its origin very far back, as it now occurs in the vast majority of flowers; a few *naked* flowers exist, but in studying them we are at once met with the question, "Are they *primitively* naked (*i.e.* have all their ancestral forms, however far they be traced, also been naked) or are they naked by reduction, *i.e.* by the loss of a perianth possessed at some period by their ancestry?" Those naked flowers which occur among the Chalazogamae are probably primitively so, their other characters attesting their antiquity, and perhaps the Gramineae and some of the lower Dicotyledons may also be included here, but such flowers as Achlys, Euphorbia, Altinga, &c. are certainly naked by suppression, occurring as they do in families most of whose flowers are not naked.

The origin of the perianth is a subject beset with difficulty; there are various explanations possible. It may have been derived from true vegetative leaves which gradually grew closer to the stamens and carpels, or from sporophylls (probably stamens) which gave up their spore-producing function, and in consequence probably became larger by the diversion of the food materials formerly given to the spores; or again, it is possible that both these views have some truth in them. However it may be, it is probable that the perianth first appeared as a few greenish or brownish coloured leaves at the base of the flower, and, by covering the stamens and carpels in the bud, performed for them the important function of protection from the weather. True simple perianths of this type occur in some of the lower cohorts both of Monocotyledons and Dicotyledons. We have again to be on our guard against cases in which abortion of part of a double perianth has occurred, *i.e.* against true *apetalous* flowers.

With the advance of insect-pollination, specialisation is shown in the perianth, and in most flowers now existing there is an outer series or whorl of greenish or brownish protective *sepals* forming a *calyx*, and an inner series or whorl of more or less brightly coloured *petals* forming a *corolla*, which aids in the attraction of insects. Most probably this inner series of leaves has been derived from the stamens; when the latter lose their sporophyll function, as in double flowers, they readily become transformed into petals. Transition forms occur in Nympheae; and are sometimes quoted as proofs of the origin of stamens from petals; the argument is equally good if reversed, and it is also *à priori* far more probable in this form, as a moment's consideration of the intermediate forms will show.

Concrescence is frequent in the perianth, *e.g.* in Sympetalae, and between perianth and stamens. Irregularity is also common.

Descriptive Terms, &c. Flower with perianth, *chlamydeous*, without, *naked* or *achlamydeous*; with one whorl of perianth, *haplo-* or *mono-chlamydeous* or '*incomplete*' (*apetalous* if the phenomenon is due to suppression of corolla), with two whorls, *di-* or *diplo-chlamydeous* or '*complete.*' Perianth with leaves of one kind only (*tepals*) *homochlamydeous*, of two kinds (*sepals* forming a *calyx*, and *petals* a *corolla*), *heterochlamydeous*.

The perianth (calyx, corolla) may be *hypo-*, *peri-*, or *epi-gynous*; of free organs (*poly-phyllous*, *-sepalous*, *-petalous*) or concrescent (*gamophyllous*, *-sepalous*, *gamo-* or *sym-petalous*); in the latter case the concrescent part or *tube* bears the free *lobes*, *teeth*, or *segments* together forming the *limb*. It may also be *regular* (*actinomorphic*) or *irregular* (*zygomorphic*, or *asymmetrical*). If it fall as the bud opens, it is *caducous*, just after fertilisation, *deciduous*, if it remain unwithered round the fruit, *persistent*, withered, *marcescent*, enlarged, as in Physalis, *accrescent*.

A homochlamydeous perianth may be *sepaloid* (looking like a calyx in colour and texture) or *petaloid* (like a corolla).

The aestivation is described in the terms given above.

The sepals are commonly leafy and green, but sometimes more or less woody (some Myrtaceae, &c.), or brightly coloured (Clerodendron, some Ranunculaceae, &c.). In many epigynous flowers they are much reduced, *e.g.* in Umbelliferae and Rubiaceae. In Compositae they are frequently represented by a *pappus* of hairs or bristles. If concrescent, the calyx is described by the terms given for the corolla, below. In Malvaceae, some Rosaceae (*e.g.* Potentilla) and Lythraceae there is an *epicalyx* of apparent stipular nature (see also Dipsaceae).

The petals are usually of some other colour than green, and of delicate texture. They may be narrowed at the base, as in wallflower, into a *claw* (*unguiculate*), fringed with hair-like teeth, as in pinks (*fimbriate*), *bi-fid*, *tri-fid*, &c. (cf. leaves) or divided into several long segments (*laciniate*) ; they may be *spurred* (with long hollow projection, as in Viola), *saccate* or *gibbous* (with projecting broad pouch), *scaphoid* (boat-shaped, as in Loasa), &c. The general form of the sympetalous corolla may be *tubular*, *funnel-shaped*, *urceolate* (urn-shaped), *campanulate* (bell-shaped as in Canterbury bells), *rotate* (wheel-shaped with little or no tube, as in Veronica), *salver-shaped* (ditto, but with long tubular portion, as in primrose), *spurred*, *saccate*, *gibbous*, *ventricose* (swollen out all round in the basal part) ; if irregular, it may be *labiate* or *bilabiate* (with two projecting lips, as in Labiatae), *personate* (labiate, mouth closed by projecting lobe, as in Antirrhinum, &c.), *helmet-shaped*, *ligulate* (strap-shaped, as in dandelion, &c.), &c.

The shape, texture, &c. of the individual sepals, petals, calyx-lobes, corolla-lobes, is described as if they were leaves.

The Stamens or microsporophylls of a flower, taken together, are termed the *andrœceum*. In flowering plants the microspores and microsporangi are termed *pollen-grains* and *pollen-sacs*, but otherwise differ little in essentials from those of Pteridophyta.

The stamen (Fig. 6) is usually a stalked organ composed of a *filament* bearing an *anther*, the latter usually of two chief *lobes* or *thecae* united by a prolongation of the filament (*connective*). Each lobe usually contains two pollen-sacs, which split along definite *lines of dehiscence* to allow the pollen to escape.

Descriptive Terms. The andrœceum or stamens may be *hypo-*, *peri-*, or *epi-gynous* ; *epi-phyllous*, *-petalous*, or *-sepalous* (concrescent with perianth, corolla, or calyx) ; *diplostemonous* (in two whorls, the outer alternating with the corolla, and equally numerous with it);

obdiplostemonous (in two whorls, the outer opposite or *anteposed* to the petals, see Caryophyllaceae), *haplo-* or *iso-stemonous* (in one whorl, alternate to the corolla, or anteposed to it, as in Primulaceae), or in more than two whorls (Rosaceae). The stamens may be few and definite

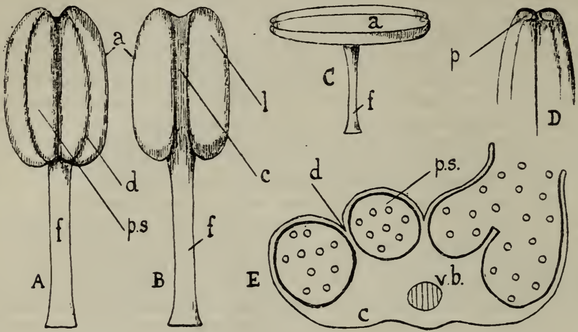


FIG. 6. STAMEN MORPHOLOGY. A, stamen with adnate anther from the front, B, the same from the back. C, stamen with versatile anther. D, tip of an anther with porous dehiscence. E, cross section of a ripe adnate anther to show pollen-sacs ; the two sacs in the right-hand lobe have just opened. *a*, anther, *c*, connective, *d*, line of dehiscence, *f*, filament, *l*, anther-lobe, *p*, pore, *p.s.* pollen-sac, *v.b.* vascular bundle.

(usually under 20, often described as *mon-*, *di-androus*, &c. according to the number) or *indefinite* (over 20, see Ranunculaceae, Rosaceae, &c.); they may be all free (*monandrous*,... *polyandrous*) or concrescent in 1, 2, 3, many bundles (*mon-*, *di-*, *tri-*, *poly- adelphous*) with free anthers, or including the anthers into one mass (*synandrous*, noun *synandrium*) as in many Araceae, Cyclanthera, Phyllanthus sp., Cucurbitaceae, &c.; they may be concrescent also with the gynœceum (*gynandrous*, Orchidaceae), or have the anthers only united (*syngenesious*, Compositae). There may be 2 stamens longer than the rest (*didynamous*, Labiatae) or 4 (*tetradynamous*, Cruciferae).

The anther may be *sessile* or on a filament; may be joined to the filament by its whole length (*adnate*, *dorsifixed*; A in Fig.), or by its base (*innate*, *basifixed*), or balanced on it, forming a T (*versatile*; C); may be *extrorse* or *introrse* (opening away from, or towards, the centre of the flower). Its dehiscence may also be *longitudinal* (A) or *transverse*, *valvular* (by lids, Berberidaceae, Lauraceae), or by *pores* (Ericaceae, Gentianaceae, &c.; D). The thecae may be twisted as in Columelliaceae, Cucurbitaceae, Cochliostema, &c. The pollen-sacs may be numerous, as in Viscum, &c., *septate* or chambered (Mimoseae, some Onagraceae, &c.). There may be *appendages* on the filaments (Zygophyllum, Amaryllidaceae, Hydrophyllaceae) or anthers (Ericaceae, Melastomaceae). The pollen may be *smooth* or *warty*, *powdery* or *coherent*, *waxy*, &c. ; it may be united into groups of 4 grains (*tetrads*, Ericaceae, &c.) or masses (*pollinia*, Orchidaceae, Asclepiadaceae).

Vestigial stamens or *staminodes* may be small and papilla-like, or may be petaloid as in Marantaceae, Canna, &c., or may form *Nectaries* as in Loasaceae.

The Carpels or megasporophylls of the flower, taken together, form its *gynœceum.* The megaspores and sporangia of Pteridophyta are represented by the embryo-sacs and *ovules* of flowering plants. The gynœceum shows much variety in structure, but there is an essential homology running through it.

The simple leaf-like sporophyll now only occurs in Selaginella and a few other forms. In the higher plants the megasporangia are replaced by ovules, usually borne on the upper edges of the carpels. The ovule contains a spore or spores (embryo-sacs). This germinates in situ and forms the female prothallus, and when the ovum is fertilised the ovule ripens to a seed. In Gymnospermae, as the name implies, the ovule (or seed) is exposed on the surface of the sporophyll, but in Angiospermae the sporophyll is folded inwards to form a hollow chamber or *ovary*, the ovules being borne on the margins (exc. Butomaceae, Nymphaeaceae, &c.) on thickened *placentae* or cushions. The tip of the carpel in the line of the midrib is now the *style*, ending in a receptive organ or *stigma* (usually sticky or hairy) for the pollen-grains. The grains, brought by wind or other agency, germinate on the stigma, and form tubes which penetrate to the ovules, carrying the male nuclei for fertilisation. Simple free (*apocarpous*) carpels of this kind are well seen in many Ranunculaceae, *e.g.* hellebore or monkshood, and in Crassulaceae, Alismaceae, &c. More commonly the carpels are concrescent or coherent (*syncarpous*). In this case several types occur; there may be as many cavities or *loculi* in the ovary as there are carpels, or there may be only one. The former case (*e.g.* Myrtus, Fig. 7) may be imagined as carpels folded in and joined, the latter (*e.g.* Corydalis, Fig. 8) as carpels meeting by their margins. Most commonly in the *multi-locular* (many-chambered) ovary the placentae are *axile*, *i.e.* on the inner walls (Figs. 5 *B*, 7), and in the *unilocular* (one-chambered) ovary *parietal*, *i.e.* on the outer walls (Figs. 5 *A*, 8), but the placentae may also be at the top (*apical*, Fig. 5 *C*) or bottom (*basal*). In the unilocular ovary of Caryophyllaceae, Primulaceae (Figs. in Pt II), &c. a peculiar *free-central* placenta runs up through the middle, the ovary looking like a multilocular ovary that has lost its partitions or *septa*.

Fig. 7.

Fig. 8.

FIG. 7. CROSS SECTION OF FLOWER OF *Myrtus communis*, showing tricarpellary, trilocular ovary, with axile placentae.

FIG. 8. CROSS SECTION OF FLOWER OF *Corydalis cava*, showing bicarpellary, unilocular ovary, with parietal placentae.

The concrescence of carpels may also include the styles, or the styles and stigmas. Branching or multiplication (p. 70), the formation of false septa (below), epigyny (p. 72), and other phenomena, often further complicate the morphology.

Details of the internal structure of the ovule must be sought elsewhere; a few notes must suffice here. The ovule (Fig. 9) is borne by a stalk or *funicle* (*f*) upon a more or less swollen *placenta* (*pl.*), and consists of a mass of tissue, the *nucellus* (*nu*), enclosed in one or two coats (*integument*, *ii*, *oi*) which spring from the base (*chalaza*, *ch*) of the ovule and leave a narrow opening (*micropyle*, *m*) at the apex. The nucellus contains one (or sometimes more than one) large cell, the megaspore or *embryo-sac* (*e*). This germinates in situ and in most Gymnospermae produces a mass of tissue (*endosperm*) filling up the interior of the sac and bearing archegonia near the micropyle. In Angiospermae there are usually only a few nuclei or cells produced, as in Fig. 9. The original spore nucleus divides to form eight, of which two unite to form a new central nucleus (*n*), while three at the micropylar end form the *egg-apparatus*, three at the other end the *antipodal* cells (*a*). The egg-apparatus is composed of three cells, an *ovum* (*o*) and two infertile *synergidae*; the antipodal cells appear to be usually functionless. The pollen tube (*t*) passes from the stigma down the style, carrying the male cell-nuclei. It may enter the ovary and pass into the micropyle (*micropylar*, *porogamic*, or *acrogamic* fertilisation) or burrow in the carpel wall and through the funicle and chalaza to the embryo-sac (*chalazogamic* fertilisation, see Chalazogamae).

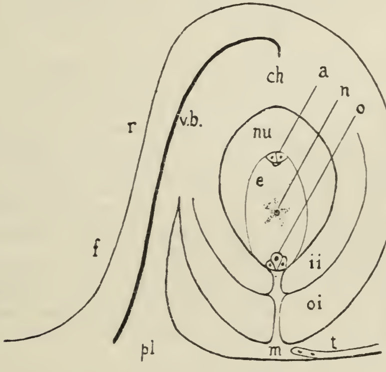


FIG. 9. DIAGRAMMATIC LONGITUDINAL SECTION OF AN ANATROPOUS OVULE. *pl*, the placenta, *f*, funicle, united to side of ovule forming the raphe, (*r*); *v.b.*, vascular bundle, *ch*, chalaza of ovule, *ii* and *oi*, inner and outer integuments, *m*, micropyle; *nu*, nucellus, containing *e*, embryo-sac, in which are *o*, the ovum with the two synergidae, *n*, the central nucleus, and *a*, the antipodal cells. A pollen-tube, *t*, is approaching the micropyle.

One of the male nuclei fertilises the ovum, forming the zygote; the other in many cases (and perhaps usually) unites with the central nucleus, which then divides rapidly to form a mass of *endosperm* cells filling up the embryo-sac. This endosperm is thus not homologous with that of the Gymnospermae. The zygote grows into the embryo, and feeds upon the stores made by the parent plant in the endosperm; the ovule ripens to a seed.

Descriptive terms, &c. The gynœceum (often called ovary, though this name belongs strictly to the hollow portion[1]) or carpels may be *superior* (occupying apex of torus above andrœceum) or *inferior* (sunk in torus, with epigynous stamens); *apocarpous* (if free), or *syncarpous* (if concrescent carpels); of 1, 2, 3, ... ∞ carpels (*mono-*, *di-*, *tri-*, ...*polycarpellary*); in spirals or whorled; *isomerous* or *oligomerous* (p. 70); *radial* or *zygomorphic* in symmetry (p. 31).

In single carpels the placentation is usually *marginal* (*cf.* Ranunculaceae, Leguminosae); in a concrescent gynœceum it may be *axile*, *parietal*, *free-central*, *apical*, *basal* (see above).

The ovary may be *unilocular* or *1-celled* (with one chamber, cell, or loculus), *bi-locular* or *2-celled* (with two), *tri-locular*, &c., to *multilocular* (with many cavities; often used for ovaries with more than one cavity). The imaginary inner join of the edges of the carpels in a concrescent ovary is called the *ventral suture*, the seam at the midrib the *dorsal suture*. In a unilocular ovary there are sutures at the junctions of the carpels.

The placenta may bear one or many rows of ovules, or a single row, or one (*solitary*) or two ovules; these points are important in taxonomy.

The partitions chambering the ovary are called *septa* or *dissepiments*. *False septa* (*spurious dissepiments*) or outgrowths of tissue chambering the ovary into more loculi than are customary with its particular number of carpels and style of concrescence, occur in Cruciferae, Linum, Astragalus, Gaylussacia, &c. *Cf.* also Labiatae, Nolanaceae, and note the peculiar morphology of Punica and Mesembryanthemum.

The general shape of the gynœceum as seen in silhouette, and its texture, &c. are described as for a leaf.

The style if present may be long or short, cylindrical, terete, *filiform* (thread-like), ribbed, curved, &c. It is usually *terminal* (springing from the summit of the ovary) but may be *lateral*, or *gynobasic* (see Labiatae). It may be single, or there may be as many, or twice as many, styles as carpels.

The stigma or stigmas may be *sessile* (fig. 5 A, p. 72) or on a style; terminal or lateral on the style; *simple* (unbranched) and then often *capitate* (head-like, fig. 5 C); *lobed* (branched into large branches with but small bays or *sinuses* between them, fig. 5 A), *bi-*, *tri-*...*multi-fid* (with 2, 3...many longer branches, fig. 5 B), *radiate* (as in poppy); sticky, hairy, smooth, &c. When branched, the branches are usually as many as the carpels, but in Euphorbiaceae, &c. they are more.

The ovule may be sessile or stalked (*funiculate;* the funicle is described if of special interest); *erect*, *ascending*, *horizontal*, or *pendulous*, according to the angle it makes with the horizon when on the placenta, the flower held erect (fig. 5, A, B, C, p. 72). It may be *orthotropous* (or *atropous*), when continuing in a line with the funicle so that the micropyle is away from the latter, as in Polygonaceae, *anatropous* (fig. 9) when reversed and attached at the side to the funicle, the latter then forming a ridge (*raphe*) on the side of the ovule

[1] The term *pistil*, nominally equivalent to gynœceum, is generally used as meaning the whole gynœceum if syncarpous, the single carpel if apocarpous.

(this is the most common case), *amphitropous*, when the funicle is attached to the middle of the ovule, forming a T, also a common case, *campylotropous*, when the ovule itself is curved into a U shape so as to bring micropyle and chalaza side by side, as in Cruciferae, &c. Whether the raphe is upwards or downwards (Fig. 5, A, B), dorsal (away from the centre) or ventral (on the side next the centre or the flower, Fig. 5, C), is often of much taxonomic importance.

The Floral Diagram is a most useful method of expressing many of the important features in the morphology of the flower. It represents an imaginary section through the bud, taken (if such were possible) so as to pass through the ovary and anthers, and through the parts of the perianth where the æstivation is most clearly shown. With the exception of the hypogyny or epigyny, the diagram shows most of the characters that are usually necessary for identifying the natural order, and hence is of much use in classification. A number of diagrams are given in Part II. and should be carefully compared with the flowers themselves. The diagram may also be used (*cf.* Polygonaceae in Part II.) to express theoretical views as to multiplication or suppression of organs, &c.

In drawing a floral diagram we put in at the top the original stem upon which the flower is a branch, and at the bottom the bract, to mark the orientation. Upon the axis of the flower itself there are usually one or two bracteoles, as we have seen. The parts of the flower usually follow certain definite rules in their orientation to the bracts and bracteoles. Only the calyx need be considered, as the inner whorls have their arrangement determined by the outer. Whilst, as we have seen, the parts of the flower are usually condensed into whorls, the calyx most commonly develops in a spiral way, the sepals appearing in consecutive order rather than simultaneously. The general rule, to which however there are frequent exceptions, in the formation of new organs at the growing point, is that each organ develops in the widest space left between its immediate predecessors. The position of the bracteoles illustrates this. When there is one posterior bracteole the parts of the flower are usually three in each whorl and the odd (first) sepal is anterior, as *e.g.* in Zingiberaceae (*q.v.*). With two bracteoles and three sepals the first sepal lies nearly opposite the upper bracteole and the odd sepal is median (either anterior or posterior). With two bracteoles and five sepals the same is the case (see Caryophyllaceae and Leguminosae). The arrangement is the same if the sepals appear simultaneously. If only two sepals occur they are placed antero-posteriorly (*e.g.* Cruciferae).

We now put in the other parts in their exact relationships. When cohesion of parts occurs, they are joined by lines, as in the calyx of Silene (Caryophyllaceae, Part II.); sometimes this is omitted, *e.g.* in the corolla of the diagram of Compositae, but it is best at first to be strictly exact. The anthers are drawn in section, showing the lobes and the extrorse or introrse opening. The ovary and ovules are also drawn in section to show the placentation, &c. When the stigmas are over the placentae, as in Cruciferae, they may be marked as is there done, and in cases like Compositae or Gramineae, where the ovarial structure does not show their position, this should also be done. The æstivation must also be attended to. For floral diagrams of many orders see Eichler's *Blüthendiagramme.*

Floral Formulae afford a convenient mode of expressing the number of parts of the flower and some of the chief features in their arrangement, and are largely used in Part II. The calyx, corolla, andrœceum and gynœceum are represented by the symbols K, C, A, G, respectively (perianth by P). After the symbol follows the number of parts; if the number be enclosed in a bracket it means that the parts are united, if not, that they are free. Thus, K (5) means "calyx of 5 sepals, gamosepalous," A 3 means "andrœceum of 3 stamens, polyandrous." If there are two numbers with a + sign between them, two alternating whorls are signified, *e.g.* A 3 + 3 means that the andrœceum is of two whorls of 3 stamens each. The ovary if inferior is represented by the symbol $\overline{G}$, if superior by $\underline{G}$.

Description of Flowers in technical language. The student should describe every flower he dissects, and draw its floral diagram. At first it will be well to select flowers whose diagrams are given in Part II. The descriptive terms used are given above.

The following short descriptions of common flowers will serve to show the order in which the parts are described, and the general form of a description.

Ranunculus bulbosus (buttercup).

Flowers terminal, solitary, on long angular and furrowed peduncles, regular, hermaphrodite, hypogynous. Sepals 5, polysepalous, oval, coloured at the edge, reflexed, with shaggy hairs. Petals 5, polypetalous, roundish, concave, with wedge-shaped basal nectaries, bright yellow. Stamens ∞, polyandrous, spiral; filament yellow, slender; anther linear, adnate, extrorse. Carpels ∞, apocarpous, superior, collected into a nearly spherical head, greenish; stigmas sessile, recurved; ovules solitary, ascending, anatropous.

Taraxacum dens-leonis (dandelion).

Flower-heads on long scapes, involucrate; the outer leaves of the involucre linear, acute, recurved, in several rows; the inner erect, in one row. Common receptacle flat, naked. Flowers all ligulate, hermaphrodite, epigynous with pappose calyx. Corolla sympetalous, ligulate, with 5 teeth, bright yellow. Stamens 5, epipetalous, with yellow introrse syngenesious anthers. Ovary inferior, compressed, unilocular; ovule 1, basal, erect, anatropous; style filiform, bifid at apex; stigmas upon the inner surfaces of the branches.

For further details see such books as Lindley's *Descriptive Botany*.

We pass on to deal with the special ecology of the flower, the general principles of which have already been set forth.

Wind-Pollination *or* ***Anemophily***, as we have seen (p. 60), was probably the earliest method of pollen transport from flower to flower. Many anemophilous flowers exist at the present day, and in considering them we are met with the usual difficulty of deciding whether they are primitively so (p. 75) or have become so by degeneration from entomophilous forms. When in a family whose members are mostly insect-pollinated we meet with one or two anemophilous forms we are fairly safe in calling these degenerate; such cases are Artemisia in Compositae, Pringlea in Cruciferae, Poterium in Rosaceae, and probably Thalictrum in Ranunculaceae (see Part II.); intermediate cases of more doubtful nature are seen in Plantaginaceae, Polygonaceae (Rheum and Rumex), Salicaceae, &c. With the exception of the Gymnosperms and the catkinate families (Betulaceae, Fagaceae, Juglandaceae, &c.), which we know from other evidence to be of a very ancient type, we cannot say with any certainty that any anemophilous flower now existing is really primitively so. Hence we can only point out the general characters of anemophilous flowers without being sure in every case whether they are true anemophilous characters, evolved entirely in anemophilous plants, or are secondary, derived from characters of an entomophilous ancestry. The most striking feature is perhaps the absence of the entomophilous characters; the flowers are usually inconspicuous (most often without a corolla), scentless and honeyless, and have rarely any tube-formation or irregularity. The chief positive characters are an abundance of freely exposed powdery pollen, and large stigmas to catch it.

An abundance of pollen, to compensate for the enormous waste in transport, is a prime necessity. This in the existing Gymnosperms and catkinate orders, is effected by the presence of a great number of stamens; in Gramineae, Cyperaceae, Potamogeton, Empetrum, Littorella, Urticaceae, &c. there are few stamens, but very large anthers; in Ricinus the stamens are branched (this is distinctly a recently acquired character, for it is not found in others of the order). The stamens all ripen at the same time, instead of successively as in entomophilous flowers (see Thalictrum). The pollen is dry and incoherent so that it blows about easily. It must be as far as possible protected from rain; in most cases this is partly effected by the fact that the anthers only open in dry air; in the catkins the bract forms a pent-house over the stamens, in Urticaceae the stamens are folded inwards until the moment of dehiscence, in Gramineae they are protected by the glumes and only emerge from them in dry air, and so on. The pollen must be freely accessible to the wind; in the catkin orders, Platanus, &c. the pendulous inflorescence is easily moved by wind, and the pollen, which often collects on the upper surfaces of the bracts, is shaken out. In the flowers with few stamens, the filaments are usually long and projecting, the anthers usually versatile. In Grasses, &c. the stamens are pendulous, the flower itself in Rumex. In Urticaceae the pollen is expelled from the anthers by an explosion. In the gynœceum, most anemophilous flowers have large bush-like stigmas, much larger and rougher than those of entomophilous flowers, and freely exposed so as to have the best chance of catching the floating pollen grains. The most remarkable is perhaps the stigma of Zea. Many, *e.g.* the catkin families, flower before the leaves appear; others, *e.g.* Grasses, &c., have the inflorescence well above the vegetative shoot, and are often of social habit. Both these facts tend to economical pollination. The number of ovules is generally very small, often only one. This may be correlated with the fact that there is little chance of sufficient pollen reaching the stigma to fertilise many ovules, whereas in entomophilous flowers the pollen clings together in masses. The most notable exceptions are Juncus and Populus. Dichogamy (see below) is common in anemophilous flowers, and, for some unknown reason, it is nearly always protogynous. For further details see the orders and genera mentioned, also Sparganium, Triglochin, Ulmaceae, Elaeagnaceae, &c.

Insect-Pollination** or **Entomophily is found in a majority of flowers, and adaptation to it has apparently been very important in the evolution of most of the higher groups. The evolution of the insects apparently went hand-in-hand with that of the flowers and it is best to deal with both together. The highest types of flower on the whole are suited to the highest types of insect, but lower types of both exist in profusion. Hermann Müller has divided flowers into a number of classes according to their degrees of specialisation in this respect. Anemophilous flowers are grouped together in a class W, while entomophilous flowers are mainly placed in seven other classes, Po, A, AB, B, B′, F, H, considered below.

The *insects* which visit flowers belong to various groups, of which the most important are:

(1) *Hemiptera* (bugs, &c.): no special adaptations to floral diet; few flower-visiting species.

(2) *Coleoptera* (beetles): many flower-visiting species. The beetles are as a rule only able to lick freely-exposed honey, their tongues being very short; a few have tongues 3 to 6 mm. long. The commonest flower-visiting genus in Britain is the small bronze-black Meligethes.

(3) *Diptera* (flies): very numerous flower-visiting species. The mouth-parts are often highly modified for feeding on honey and pollen. For our purpose we may divide the flies into long-tongued and short-tongued. The former include the Syrphidae (drone- or hover-flies) and a few others, the latter all the remaining forms. The former confine themselves to a floral diet and are clever in finding concealed honey; their tongues vary in length from 4 to 12 mm. Many flowers are specially adapted to, and visited by, them. The most common genera in Britain are Eristalis, Platychirus, Syrphus, Rhingia, &c. The short-tongued flies are much less highly adapted to floral diet; many feed also on carrion, &c. (some flowers, *e.g.* Arum, Rafflesia, Stapelia, &c., avail themselves of this habit by a carrion-like smell); their tongues are short (less than 4 mm.) and they are rarely skilful in finding concealed honey. The commonest flower-visiting genera in Britain are Lucilia (small blue-bottle), Anthomyia, Scatophaga (dung-fly), &c.

(4) *Hymenoptera* (ants, sawflies, ichneumons, bees, wasps, &c.): mostly flower-visiting species. They are all short-tongued except the bees, which are the most important group of insects in relation to the evolution of flowers. They collect both pollen and honey; the former is usually carried in the brushes of hairs on the hind-legs, into which it is brushed by the hairs on the tarsi. We may divide bees, for our purposes, into short- and long-tongued, according as the tongue is shorter or longer than 6 mm. To the former group belong such small bees as Halictus, Andrena, &c.; to the latter chiefly the hive-bee (Apis) and the humble-bee (Bombus). There are a great number of flowers adapted to pollination by bees, especially the long-tongued forms.

(5) *Lepidoptera* (butterflies and moths): most species flower-visiting. Their tongues are on the whole about as long as those of bees, but some species, mostly Sphingidae (hawk-moths), have them of extraordinary lengths, *e.g.* in Britain that of *Sphinx convolvuli* is 80 mm. long, whilst some forms even reach 300 mm.

For further details see Müller's *Fertilisation of Flowers* and entomological text-books.

Insects have to be attracted to the flower and paid in useful material—honey, pollen, &c.—if they are to be regular visitors of any real use. When insect-pollination began, the attraction of insects from a distance, and their remuneration on arrival, were probably both functions of the andrœceum. Afterwards differentiation began, and other modes of attraction and remuneration appeared. Pollen is an important part of the food of many insects; many flowers depend largely upon it as an attraction. There exists a class of flowers, **Po** in Müller's classification, which only furnishes pollen to visitors, having no honey. Such flowers are Hypericum sp., Spiraea sp. (*e.g.* common meadow-sweet), Helianthemum, Cytisus sp., Clematis sp., *Rosa canina*, &c. It is highly improbable that any of these are primitive pollen-flowers; they are probably mostly flowers which have gradually lost their honey-secreting functions. They belong, structurally, to various groups of the honey-flowers, *e.g.* AB and H. They are always, however, in ecological work, retained as a separate class; their visitors are mostly flies and pollen-collecting bees. Interesting cases of division of labour among the stamens of a single flower, some providing pollen for insects, some for pollination, occur in Cassia, Heeria, Commelina, &c.

The secretion of *honey*, by special organs termed *nectaries*, is almost universal in entomophilous flowers. The nectaries are usually at the base of the flower. They may be upon the receptacle as in Malva, Compositae, &c., calyx as in Coronilla, petals as in Ranunculus, Swertia, &c., stamens as in Cruciferae and Caryophyllaceae, or carpels as in Caltha, Allium, &c. Sometimes they are themselves modified flower-leaves as in Nigella, Aconitum, &c., or parts of them as in Viola. The honey is protected from rain in many ways; we shall consider the chief of these in dealing with the gradual evolution of tubes in flowers. Hairs often serve as extra protections, *e.g.* in *Geranium sylvaticum*, Malva, Swertia, &c. The stamens, or parts of them, cover the honey in Campanulaceae, &c., and so on. In many plants there is no free honey, but insects (especially bees) bore into certain succulent tissues and suck the sap. Interesting examples are found in Orchis and many other Orchidaceae, Liliaceae (*e.g.* Brodiaea), &c.

A few flowers, *e.g.* Dalechampia, attract insects by providing resin or other useful substances.

Attraction of insects from a distance is largely, so far as we can tell, the function of the brightly coloured corolla (see Colours of Flowers, below); in some cases there is a coloured calyx or bracts, or the stamens are exposed, as in many Acacias, Callistemon, &c. The conspicuousness is often increased by massing of the flowers (p. 66).

Whilst conspicuousness and colour are doubtless great attractions to insects, *scent* is even more powerful, as a consideration of such cases as *Convolvulus arvensis* and *Calystegia sepium* will show, and as is evidenced also by the great number of visitors received by many sweetly-scented and inconspicuous flowers. It is necessary to remember the limitation of our own sense of smell, and not to conclude that because we cannot smell it, a flower has no scent. There are several experiments tending to show that bees can smell flowers which to us seem scentless. The carrion smell of such flowers as Arum, Stapelia, &c. repels all visitors but the carrion-loving flies, by which alone these flowers are visited and pollinated.

Insects, especially small flies, often visit flowers for shelter, chiefly such as hang downwards or have hooded corollas, and in this way a certain amount of pollination is probably effected.

One great direction followed in evolution has been the formation of tubular structures in flowers, narrowing the entrance to the honey. A simple flower, hypo-, peri-, or epigynous with a convex or flat torus, and without concrescence of its organs, usually has its honey freely exposed, so that it may be licked by the shortest-tongued insects. Many flowers of this kind exist, and form a biological class, "flowers with freely exposed honey." It is termed for brevity class **A**, and contains such flowers as those of species of Saxifraga, Parnassia, Galium, most Umbelliferae, Hedera, &c. Observation shows that the insect visitors to flowers of this class are chiefly short-tongued; bees and Lepidoptera rarely visit them[1]. They are exposed to the risk of having the honey spoiled by rain. The upward evolution of flower-visiting insects seems to have proceeded in the direction of longer-and-longer-tongued forms. Their cleverness, too, in finding concealed honey, or in dealing with hanging or irregular flowers, is largely correlated with the length of their tongues. The concealment and protection of the honey, by the formation of a tubular structure in the flower, seems to have kept pace with the lengthening of the insects' tongues. The next stage is represented in existing flowers by those which form the class **AB**, "flowers with partially concealed honey." Such are Ranunculus, Sedum, Cruciferae, Fragaria, Potentilla, &c. The visitors require tongues of 2 to 6 mm. or more in length. Observation shows that the actual visitors are mainly those whose tongues are long enough to fit the flowers. Bees and Lepidoptera visit flowers of this class more often than those of class A, but the bulk of the visitors are the short-tongued Hymenoptera, and the longer-tongued flies. From a morphological point of view the chief interest is to notice the ways in which concealment of the honey is effected. In Ranunculus, &c. it is merely by the position of the stamens, &c., a method which does not admit of much further elaboration. In Cruciferae the sepals stand stiffly erect, thus making the lower part of the flower a narrow tube, as is well seen in wallflower. In Fragaria, Potentilla, &c. we see the beginnings of perigyny of the flower.

Following any of the evolutionary lines we have thus indicated, many flowers probably arrived at the further condition represented in the existing flowers of class **B**, "with fully concealed honey." Such are Anemone § Pulsatilla,

[1] The student should spend a few fine afternoons in observing the insect visitors to flowers of the various classes. Even if unable to recognize the insects he will be able to observe their length of tongue, size of body, &c., and compare these observations with those made on the depth of tube in the flower and so on. He should also notice the numbers of visitors of each kind that visit the flowers and compare the proportions with the class of flower; see below and refer to *Annals of Bot.*, June 1895, and books mentioned above.

the Silenoideae (Caryophyllaceae) with shorter tubes (such as Gypsophila), Geranium, Epilobium, Rubus, Polemonium, Veronica, Mentha, Calluna, &c. Some of these attain their purpose by concealing the honey with the stamens, &c., others by aid of the calyx, which shows a further advance in being gamosepalous. Others again are more deeply perigynous, the receptacle becoming more deeply hollowed and tubular, whilst in the four genera last mentioned we find the new and important phenomenon of a sympetalous corolla. The visitors to flowers of this type are the smaller bees, many Lepidoptera, and the long-tongued flies, with a few of the larger bees. Comparing the flowers of class B with those of class A, we see that they have gained in the protection of the honey, pollen, carpels, &c., but at the expense of losing the visits of the shorter-tongued insects. This loss, however, is more than compensated for by the superior cleverness and activity of the longer-tongued visitors; the latter, too, are usually found to confine their visits during one flight to few or even to one species of flower, so that much less pollen is wasted by them than by the more stupid insects which visit flowers more indiscriminately. The advantage to an insect of keeping (as bees largely do) to one kind of flower as long as possible, is evident, for the insect will, so to speak, 'get its hand in' for the particular flower, and be able to visit far more flowers in a given time than if it frequently changed from one species to another.

A few of the Campanulaceae, most Dipsaceae, and the Compositae have flowers with depth of tube, &c. as in class B, but as they have aggregated inflorescences and are thus more attractive to insects, besides being on a higher level in other biological features, they are grouped together as a class **B′** ("flowers with fully concealed honey, in aggregated inflorescences").

A further lengthening of the tube of the flower, beyond the stage we have considered, will exclude the shorter-tongued insects and allow only bees and Lepidoptera to get the honey. The highest stage in this line of evolution is seen in many flowers of class **F** (Lepidoptera flowers). Silene (the longest-tubed forms, like *S. inflata*, *nutans*, &c.), Lychnis, &c., have a gamosepalous calyx, Oenothera, Daphne sp., Cuphea, &c., a long tubular receptacle, some Rubiaceae, Gentians, Ericas, Primulas, &c., a long tubular gamopetalous corolla.

Most of the flowers so far considered have radial symmetry, and stand more or less erect. When zygomorphism occurs, or a hanging or horizontal position of the flower, or special concealment of the honey in any way, as in many Leguminosae, Orchidaceae, &c., it is found that the flowers are chiefly visited by long-tongued bees, which are almost the only insects clever enough to obtain the honey in such cases. The length of tube is usually 6—15 mm., or that of bees' tongues; the flowers are visited chiefly by long-tongued bees and form the class **H** ("bee-flowers").

Whilst, as we have said, most flowers are visited by all the insects best suited to them and have therefore a considerable variety of visitors, there are numerous cases of more special restriction. Thus the carrion smell and appearance of the flowers of Rafflesia, Stapelia, Ceropegia, Aristolochia, Arum, Helicodiceros and many others cause them to be visited only by carrion-loving (short-tongued) flies; they form a sub-class "carrion-fly flowers." The flowers of Epipactis, Scrophularia, Symphoricarpus, Cotoneaster, &c. are "wasp-flowers." A number of flowers of class F, *e.g. Silene noctiflora*, *Oenothera binnis*, *Nicotiana tabacum*, &c., emit their scent only at night, thus attracting night-flying moths. Some of these, and Cereus, &c. only open at night. Such flowers have usually light yellow or white colours. Lastly, mention may be made of the very special mutual adaptation seen in Yucca, Ficus, Angraecum, &c.

Many flowers of high type, with honey at the base of the tube, have their arrangements vitiated by the habit which certain humble-bees (especially *Bombus terrestris*) have of boring holes in the tube, and thus obtaining the honey without pollinating the flowers. Most flowers of the common bell-heathers (Erica) show a perforation at the base of the corolla thus made. If only humble-bees used it, the loss would not be so great, but it is used by hive-bees and wasps also, which do not bore the flowers themselves or only rarely. Other flowers that are often bored by Bombus are Aconitum, Dicentra, Lamium, Linaria, Nepeta, Salvia, &c.

If in any locality the insect visitors to all the flowers be observed, and the number of species of each group visiting all the flowers of each class be recorded, a test of the general flower theory is obtained. A few examples may be quoted from a paper on the British flora (*Ann. of Bot.* 1895).

For each flower the number of species of insect-visitors of each class is recorded, and the totals thus obtained are given here :

Flower Class	No. of plant-species	Long-tongued Bees	Short-tongued Bees	Lepidoptera	Long-tongued Flies	Short-tongued Flies	All other Insects	Total	Average per flower-sp.
A	12	4	7	7	37	130	90	275	23·0
B′	12	43	16	49	90	120	59	377	31·5
H	25	49	7	21	28	30	20	155	6·2

This shows clearly, especially if calculated as percentages, the preferences exhibited by the various insect groups for the flowers whose tube-depths are best suited to them. The visitors to the flowers of class H are few in number, but by far more industrious than most of the visitors to class A. Class B′ in Britain obtains the lion's share of visits —this is explained by the abundance of Compositae in the flora. Many authors class together as *allotropous* all the shortest-tongued insects (*i.e.* short-tongued flies and all miscellaneous insects) and the corresponding flowers (classes Po, A, AB), as *hemitropous* those insects of medium-length tongues (short-tongued bees, long-tongued flies and all Lepidoptera but the hawk-moths) and the flowers of classes B and B′, and as *eutropous* the long-tongued bees and hawk-moths, and the flower-classes H and F. For a number of flowers observed in Britain the percentages were as follows :

Class of Flower	p.c. of total insect-visits	p.c. of Eutr. insect-visits	p.c. of Hemitr. insect-visits	p.c. of Allotr. insect-visits
Allotropous	34·7	5·4	21·4	48·7
Hemitropous	50·8	54·6	62·7	43·0
Eutropous	14·4	40·0	15·9	8·3

These percentage numbers give a measure (for the particular region and period of the year) of the attractiveness to insects of the different sorts of flowers. The first column shows the attractiveness to insects in general, the others the attractiveness to different groups. When a number in one of the latter columns exceeds the one in the first column, it shows a preference by that kind of insect for that kind of flower ; thus the hemitropous insects show a great preference for hemitropous flowers (62·7—50·8) and eutropous for eutropous flowers (40·0—14·4).

When a comparison is made, upon the lines just indicated, between the floras of different countries, it is found that the proportions of the various classes differ a good deal. Thus in the extreme North of Europe eutropous insects are wanting, and there are few eutropous flowers. Those flowers that do occur are found either to have increased vegetative reproduction, or to have shorter tubes enabling the hemitropous visitors to obtain the honey. Thus the insect fauna and its distribution are important factors in determining the geographical distribution of plants. Usually the number of species visiting any one flower that is regularly insect-pollinated is at least two or three and often very many; if this flower be studied in different countries it will be found visited by different species, but of the same biological class, as regards length of tongue, &c. (*e.g.* short-tongued bees may be replaced by long-tongued flies). There are however a number of cases of mutual adaptation of one particular flower and one particular insect, and in these cases the distribution of the latter regulates that of the former. The best known case is that of Bombus and Aconitum (*q.v.*, and see Bryonia, Angraecum, Yucca, &c.).

Floral Mechanisms etc. It is evident, that if a visiting insect is to be of any use, that part of its body which touches the pollen must also be the part to touch the stigma. In a declinous plant this is easily enough managed, but difficulties arise when the flower is hermaphrodite. So long as insects merely sprawled about flowers, feeding on pollen, it would not, perhaps, be much disadvantage to have the stigmas at a distance from the anthers, as insects would probably touch them sooner or later; there would however probably be at least as much self- as cross-pollination, even with insect visits. When nectaries and perianth were more fully evolved, the track taken by the insect visitors would be more definite; the same species of insect would visit the same species of flower always in the same manner. It would now become a necessity to place anthers and stigmas so as to touch the same part of the insect, *i.e.* they must generally be close together, and so cause difficulty in avoiding pure autogamy. The ways in which this is effected present a bewildering variety, but all have the same general underlying principle, to ensure cross-pollination as far as may be done without seriously affecting the certainty of setting seed.

The most certain mode of avoiding autogamy, while keeping anthers and stigmas in positions to touch the same portion of an insect visitor, is of course *declinism.* This was perhaps common among the early flowering plants, but is not so now; it is found in a number of cases, however, most of them apparently derived from hermaphrodite ancestry (see p. 68).

Diœcism has the serious disadvantage of requiring a number of male plants whose sole function is to produce pollen; the chance of pollination, too, is less than in monœcism, and here again less than in cases of hermaphroditism.

Another condition preventing autogamy is *self-sterility*, *i.e.* incapability of a flower to be fertilised by its own pollen. This condition is little understood; the same flower varies in this respect in different countries. Corydalis sp., Abutilon sp., Passiflora sp., and others may serve as examples. It is very improbable that this character has been acquired as a preventive of autogamy.

A phenomenon of the same kind is *pollen-prepotency*. If a stigma on a plant A be pollinated from the stamens of A and from those of another plant of the same species, B, in many cases the ovules will be fertilised by the tubes of B, not of A, even if A has had a start (provided of course that the tubes of A have not reached the ovules).

Allied to these is the remarkable phenomenon of *heterostylism*[1], seen in a typical condition in the primrose or cowslip (Primula) and in Lythrum (*q.v.*). In the former two kinds of flowers are found (*dimorphism*), in the latter three (*trimorphism*), each on a separate plant; they are distinguished by the different lengths of the stamens and styles. One flower of Primula has a long style and short stamens, the other a short style and long stamens. Complete fertility (*i.e.* a full yield of fertile seed) is only obtained when pollen is taken from long stamen to long style or from short to short, which of course involves cross-fertilisation. It is evident that this *legitimate* pollination will tend to be regularly effected by the visiting insects, which behave always in the same way upon the flowers. *Illegitimate* pollination (short and long) results in few seeds and these are more or less sterile. This is a remarkable fact, for it is exactly the phenomenon seen in hybridisation, *i.e.* in crossing of two distinct species. For further details see Lythrum; *cf.* also Pontederia, Fagopyrum, Linum, Erythroxylon, Oxalis, Statice, Hottonia, Menyanthes, Pulmonaria, Faramea, Bouvardia, Mitchella, and many others. In Nolana, &c. the length of the stamens and styles is very variable.

[1] Darwin, *Forms of Flowers*.

A widespread phenomenon in hermaphrodite flowers is *dichogamy* or sex-separation in time; the pollen is ripe before the stigma, *protandry*, or the reverse, *protogyny*. A flower in which stamens and stigmas ripen together is termed *homogamous*, but true homogamy is rare. If the dichogamy be complete, *i.e.* if the first stage be over before the second begins, the result will be the complete prevention of self-pollination, while at the same time the anthers and stigmas may occupy positions as close as possible to one another, or even, by aid of movement, occupy the same position, at different times. Completely dichogamous flowers are rare, and are usually such as are so attractive to insects as to ensure being sufficiently visited for cross-pollination, *e.g.* Aeschynanthus, Canna, Clerodendron sp., and some wind-pollinated flowers, *e.g.* Parietaria. Nearly all flowers are more or less dichogamous, but there is generally a considerable period of overlap of the male and female stages, during which self-pollination is frequently possible. This is more or less guarded against by numerous mechanical arrangements, to be dealt with below. Dichogamy is a variable phenomenon, the same species showing different degrees of it in different localities, and at different periods of the year. Protandry is most common in insect-visited flowers (good examples of simple protandry are found in Umbelliferae and Caryophyllaceae), protogyny in wind-pollinated flowers; the latter also occurs in a considerable number of entomophilous forms, *e.g.* many Araceae, Paris, Colchicum, Asarum, Chimonanthus, Amorpha, Goethea, Aesculus, &c.

Simple *dichogamy with movement* of the essential organs so as to place first one and then the other in the track of an entering insect, is very common. Extreme cases occur in Aeschynanthus, some Clerodendrons, &c. Others, in which there is more or less possibility of autogamy, may be seen in Scabiosa, Lonicera, Scrophularia, Teucrium, Umbelliferae, Caryophyllaceae, Delphinium, Aconitum, Geranium, Ruta, Epilobium, Malva, and hundreds more.

Passing on to the more purely mechanical arrangements for regulating pollination, we find in the Orchids (*q.v.*) one which in nearly all cases renders the flowers incapable of pollinating themselves. These plants are perennials with much vegetative reproduction; this obviates the risk of extinction in bad seasons; they also set a vast number of seeds in every pollinated ovary. It is instructive to compare this order with the Compositae (see Part II.).

A somewhat similar state of things is found in the Asclepiadaceae, but these flowers are more visited by insects and do not set so many seeds. There are also other flowers in which self-pollination is fully prevented, but such cases are rare, and autogamy may occur if an insect visit the same flower twice. Such are Mimulus, Martynia, &c. (sensitive stigmas), Iris, Viola sp. (the open flowers), &c., and the fully dichogamous flowers above mentioned.

The most simple and successful mode of ensuring the best chance of a cross for the longest time, with the certainty (in most cases) of autogamy if the cross fails, is the *piston-mechanism* found in Compositae and some Campanulaceae, where the style acts as pollen-presenter with closed stigmas, and afterwards the latter open out. An instructive series of flowers is found in Campanulaceae, leading up to the perfected mechanism of Compositae (see Part II.). A second type of the piston-mechanism is that seen in Leguminosae (*q.v.*). Here autogamy is prevented in many cases by the fact of the stigma only becoming receptive when rubbed, so that no fertilisation can take place till the flower has been visited by an insect. We may also mention here the lever-mechanisms of Salvia and Roscoea, the pollen-cup of Goodeniaceae, &c. The mechanism of Leguminosae is curiously repeated in Collinsia, Schizanthus, Phlomis, &c. The style also acts as pollen-presenter in many Proteaceae. Many of the Compositae (Cynareae) have the mechanism varied in detail by a sort of explosive arrangement, and this is even more marked in many Leguminosae, *e.g.* Genista. Similar phenomena are seen in some Orchids, *e.g.* Pterostylis, in Caladenia sp., Candollea, Kalmia, Posoqueria, &c. This leads naturally to the mention of such other cases of sensitive and motile organs in flowers as the stamens of Berberis, Sparmannia, Portulaca, &c. (see also above, Mimulus, &c.).

A very common arrangement is for the style to project a little beyond the anthers, so as to be touched first by the insect visitor. The flower in these cases is usually nearly homogamous. Of course autogamy is nearly certain to occur, but as it will not usually occur before the cross-pollination it is likely that prepotency of the latter is the rule. Such flowers are Lamium and many other Labiatae and allied orders, many Cruciferae, Ranunculaceae, &c., and many of the 'loose-pollen' flowers mentioned below. Every gradation is found from those in which cross-pollination is the rule to those in which it rarely occurs.

The *loose-pollen mechanism* is found in the Rhinanthus group of Scrophulariaceae (Euphrasia, Bartsia, &c.), Acanthus, &c. The pollen is dry and powdery as in wind-pollinated forms. It is held loosely in a box formed by the stamens under the upper lip of the flower, so arranged that the entering insect shall open the box and receive a shower of pollen. Some of these forms are dichogamous (protandrous), others merely have the stigma projecting beyond the stamens. Transition forms occur in Euphrasia, &c. A second type of this mechanism, usually with porous opening of the anthers, is found in the hanging flowers of Borago, Solanum sp., Erica, Calluna, Cyclamen, Soldanella, Galanthus, &c.

In the *trap-flowers* the visitors are entrapped and are either suffered to depart at once by another road past the essential organs, or are captured in the female stage of the dichogamy and held until the pollen is shed. To the first class belong Cypripedium, Coryanthes, Stanhopea, and other orchids, &c., to the second Arum and other Araceae, Aristolochia[1], Ceropegia, Aspidistra, Magnolia and others.

So far we have dealt with mechanisms in regard to the favouring of cross-pollination. Arrangements for autogamy are equally common, even in most of the highest types of flowers. Thus in Compositae the final curling up of the stigmas, in a very great number of flowers the withering of the corolla, in others merely the movements of insects in visiting, bring pollen and stigma into contact with one another. Details will be found in Part II.

The most interesting mechanism of this class is the production of a second type of flower which does not open and in which therefore only self-pollination can occur. Such *cleistogamic* flowers are well seen in Viola (*q.v.*), Oxalis,

[1] Note that here a tube occurs in the flower, without any apparent reference to insects' tongues.

Lamium amplexicaule, *Salvia verbenaca*, many Leguminosae and others. They are usually produced either on shaded parts of the plants, or in the colder and darker seasons of the year. Vöchting[1] has shown that in plants that normally produce both open and cleistogamic flowers a reduction of the amount of light results in the production of the latter kind only. Other observers have shown that temperature and other conditions (those in general which reduce nutrition) are determining factors also. Though these are determining factors, and their effect in any plant is to check the formation of open flowers, cleistogamy is not a phenomenon to be put on the same level with gynodiœcism, for it is hereditary, as well as advantageous to the plant possessing it, and cannot be artificially produced in plants not showing a tendency towards it. In chick-weed (*Stellaria media*) the winter flowers tend to cleistogamy, and in water-plants the flowers when submerged are often pollinated in the bud. In Myrmecodia, &c. only cleistogamic flowers are produced. These show by various characters that they have been derived, comparatively recently, from open flowers, and may be compared with the reduced autogamous flowers of such plants as *Senecio vulgaris*, &c.

Many of the regularly self-pollinating flowers, such as *Senecio vulgaris*, Capsella, &c., have a very wide distribution. This is explained by Wallace by the supposition that small changes of climate, &c. react upon the organism in the same way as cross-fertilisation, increasing its fertility, strength of constitution, variability and so on. The wide distribution of many cross-pollinated flowers is prevented by the circumstances of insect distribution. Many wind-pollinated flowers, however, are widely distributed.

Zoophily, or pollination by animals other than insects, seems to occur in a number of plants; *e.g.* the flowers of Alocasia, Rohdea, &c. are "snail-flowers" (*malacophilous*); those of Freycinetia "bat-flowers"; those of Marcgraviaceae, Erythrina, *Salvia splendens*, Passiflora sp., Abutilon sp. and many more in the tropics of America are "humming-bird flowers" (*ornithophilous*). Most of the last-named are bright

[1] Vöchting, *U. d. Einfl. d. Lichtes a. d. Gest...d. Blüten*, Prings. Jahrb. f. wiss. Bot. 1893; Willis in Linn. Soc. Journ. xxx. 1893, p. 295, and Sci. Progr. Nov. 1895.

red flowers, more or less inclined downwards with long tubes, and no landing-places such as occur in insect-flowers, the birds hovering before the flowers. In the Indo-Malayan region many flowers are visited by sun-birds, but whether they are specially adapted to them is not known. These birds often spoil the flowers by pecking through the tube.

Colours of flowers, &c. The subject of the colours of flowers—and indeed of colour in plants generally—is one of considerable difficulty; we shall only attempt a sketch of some of the outstanding facts. The green colour of the vegetative organs is due to the presence of chlorophyll in certain specialised parts of the cell-protoplasm, known as *chloroplastids*. Green is rarely seen in corollas though there are several cases, *e.g.* Deherainea. The colours most often seen are yellowish-green, yellow, red, white, blue, and shades of these or intermediate colours; yellow and white are the most common, blue the least so. Yellow flowers nearly always possess *chromoplastids*, protoplasmic bodies containing the yellow colouring matter. Some red flowers, and a very few blue ones have chromoplastids also. Most red and nearly all blue, purple, and violet flowers have the colouring matter dissolved in the cell-sap. White flowers have colourless sap and plastids. This difference explains the fact that in the variations of colour so often seen, it is exceedingly rare for a green or yellow to pass to blue, or the reverse. All flowers, whatever their colour, seem to vary most easily towards white, and this is not difficult to understand.

This subject of colour-variation shows many points of interest. In the same individual flower, most Boraginaceae vary from red to blue as the age of the flower increases; the spots in Aesculus vary from yellow to red, the corolla of Myosotis sp. from white or yellow to blue, and so on (see Ribes, Fumaria, Diervilla, Arnebia, Cobaea, &c.). In some cases the flowers of a given plant differ in colour in different years. There are many species which show different colours in different flowers; sometimes these are special varieties or races, sometimes, as in Polygala, merely individuals otherwise exactly alike. The most striking varieties in colour may be seen in the cultivated forms, but they follow the same rules as the wild; it is found that for each species there is a certain range of colour beyond which it cannot be made to go in cultivation, and does not go in nature. By hybridisation and in other ways mixtures of colours may be produced, and every variety of shade and sometimes of variegation, but beyond certain limits the species cannot be made to pass. These limits are found to be as a rule the colours found in the genus to which the species belongs. *E.g.* in Dianthus, some species show red, some white, some yellowish or purple-violet corollas, but none blue. Now in the cultivated pinks and carnations (*D. Caryophyllus*) red, white, yellowish, and violet colours are known in every shade, mixture and variegation, but no efforts of horticulturists can produce a blue carnation. Other examples are found in the stock (Matthiola), wall-flower (Cheiranthus), aster (Callistephus) and most other cultivated flowers. Sometimes the range of colour in the species is that defined by the order rather than by the genus. A great many flowers do not normally vary in colour at all, and horticulturists sometimes find considerable difficulty in starting the variation necessary before new races can be obtained. The most common method is change of soil, manure, light, heat, &c. All these conditions have in nature certain influences on the colour of flowers (no definite rules can be framed, as two flowers of the same colour but of different species are often affected in opposite ways by the same agent), and when all are changed together, the plant seems as if it received some kind of a shock which may cause variation. Once variation in a hitherto fixed colour can be started it often continues for a long time, keeping, however, within certain limits, as we have explained. It is to be noted that, with the exception of the long cultivated hyacinth, blue flowers do not vary to yellow, even if there be yellow species in the genus. Red varies towards yellow rather than towards blue. All colours vary readily to white.

As regards the question of the meaning and function of colour in flowers there can be no doubt that it is largely bound up with pollination by insects. If however we set out only from the higher plants, we shall as usual come across cases that cannot be explained in the light of the information there obtained. The spores of Cryptogams are generally coloured, yellow or brown, less often red or green. What the meaning of this fact is, we do not know. Colours are well known to appear in many chemical reactions and it is quite likely that many colours are of this accidental kind without any particular significance in the life-history. Or it may be that the colour of spores protects them from the action of light (which is very fatal, for example, to the spores of bacteria). However this may be, yellow is prevalent in spores and pollen grains, and the conspicuous colour of many anemophilous flowers, *e.g.* Abies and other Conifers, Corylus, &c., some Grasses, and so on, is no longer a surprising exception, as it is if colours are regarded as only concerned with insect visits. If the corolla was derived from stamens, it would seem possible that its colour was yellow at first and that all the other colours are subsequent derivatives.

Of these, red and blue are probably the highest types, and are found chiefly in flowers of high organisation.

In dealing with the question of the colour-sensitiveness of the eyes of insects we must remember the limitations of our own. There is good reason to believe that many insects, and especially bees, see as colours the ultra-violet rays of the spectrum which are invisible to us. Bees show a decided preference for blue colours, butterflies for red and white (the only blue Lepidoptera-flower known is Globularia), but beyond this there is but little colour-preference in insects. Carrion flies go to meat-coloured flowers, but probably because of their carrion smell. We shall probably not be far from the mark if we say that the only preference shown by insects of low organisation is for bright rather than dull colours (they visit many dull flowers, *e.g.* Adoxa, but it is doubtless the smell that attracts). This being so, it is improbable that the earliest flower-visiting insects had much influence upon the colours of flowers; they would select the most conspicuous but would not necessarily produce any direct effect on colours. We may therefore probably assume that the early flowers were yellow and white, with perhaps a few orange or red species. When the higher forms of insects appeared, there would be a colour-selection and now we can imagine red and blue flowers appearing by the selective action of insects. It may be noted that most blue flowers belong to class H, the rest chiefly to classes B and B′; these are the classes visited by bees. Most red flowers are found in class F, and many in B, B′ and H.

In this connection mention must be made of the *honey-guides* or pathfinders seen in so many flowers—lines, streaks, or spots pointing to the entrance to the honey, and differently coloured from the rest of the corolla. In Myosotis sp. there is a yellow ring at the mouth of the tube, the rest of the corolla being blue[1], in Pelargonium there are reddish streaks on a pink ground, in Viola light streaks on a deep blue, and so on. These markings as a rule show the way to the honey, and are doubtless useful to visiting insects, and hence, by increasing the rate at which they work, to the flowers them-

[1] A classic example, for it was one of C. K. Sprengel's first discoveries; see his *Entdecktes Geheimniss d. Natur*, or biography in Nat. Science, April, 1893.

selves, but they have yet to be proved to be adaptations for this purpose; they may be phenomena accompanying changes of colour in flowers which have been retained as useful characters[1].

Anthesis, Protection, &c. The bud gradually increases in size to a certain point, after which, given the necessary warmth, turgidity, &c., it opens, or *anthesis* occurs. The period during which the flower remains open is usually roughly constant for the same species within certain limits, but different species differ enormously in this respect. Flowers usually wither as soon as fertilisation (or even pollination) occurs; flowers like those of orchids, in which autogamy is impossible, may remain open a very long time if not pollinated.

If the *time of opening* of the flowers of any species be watched, it will be observed that a few only are open at first, then the number increases to a maximum, and gradually decreases again. In the flowering of a whole genus, more than one maximum is very commonly observed (*cf.* p. 22). In a single district the flowering of any ecological class, *e.g.* A or H, tends to show a single period of greatest vigour, and this is often found to correspond approximately with the time of greatest abundance of the most suitable insects, *e.g.* short-tongued flies for class A, bees for H.

The bulk of the flowers of the North temperate zone open in summer (maximum in July), but there are many that flower in autumn or early in spring. It is an advantage to plants to flower at different periods, especially if they are nearly allied, for the competition for insect-visits is thereby lessened. It must not however be assumed that the phenomenon is an adaptation to this end; many factors influence the flowering of a plant, *e.g.* a check to the vegetative growth. A richly fed plant tends to vegetation rather than to flowering, and the significance of pruning, &c. rests largely on this fact. Plants that are to flower in early spring in temperate climates must have flower-buds laid down the preceding year and also a store of reserve food-materials with which to start growth. Such are Rhododendron, Eranthis, most of our trees, &c. The buds are usually protected by outer scaly leaves, hairs, or other arrangements. A few autumn-flowering plants show similar protections, *e.g.* Hedera, Hamamelis, &c., hence it is possible that these were once spring-flowerers, but have gradually taken to developing their buds more early.

In these spring-flowering plants we have cases, otherwise rare, of protection of flower-buds such as is seen in winter buds of leaves. Xerophytes (see Chap. III.) often show protection of flower-buds

[1] Hildebrand, *Die Farben d. Blüthen*, Leipzig, 1879, Müller's *Fertilisation of Flowers*, Wallace's *Darwinism*, &c.

against the drought of the dry season. As a rule however the calyx and corolla afford enough protection to prevent injury by cold, wet, &c. to the more delicate stamens and carpels. In hot tropical regions many flowers are protected against the heat.

Many flowers execute protective movements after they have opened; these are chiefly such as expose their pollen very freely to the weather. *E.g.* in Linum, Fragaria, Daucus, Papaver, Anemone, Bellis, &c. the flowers (or heads) curve downwards at night and in wet weather, returning to the erect position in the morning or when it is fine. The flowers (or heads) often close in dull weather or at night, *e.g.* in Anagallis, Bellis, Tragopogon, Calandrinia, and numerous others. Besides these movements there are others which only take place once. The flower-stalks often stand in different positions whilst the flower is in bud to those they occupy when it opens or while the fruit is ripening. Hansgirg divides movements of this kind (*gamo-* and *carpo-tropic*, *i.e.* before and after fertilisation) into seven types, *viz.* (1) the Oxalis type, as seen in Oxalis, Geranium sp., &c. (see Part II.), (2) the Primula type, as in Primula, many Umbelliferae, &c., (3) the Coronilla type, as in many Papilionate Leguminosae, (4) the Veronica type, as in Veronica, Cardamine, Reseda, Epilobium, &c., (5) the Aloe type, as in Muscari, Funkia, Vicia, Aloe, &c., (6) the Fragaria type, as in Fragaria, Anagallis, Aristolochia, Tussilago, &c., (7) the Aquilegia type, as in Delphinium, Aconitum, Aquilegia, *Solanum nigrum*, &c.

The Seed. In the lower classes of plants the spore (or megaspore) falls out of the sporangium and germinates upon the soil. In the flowering plants proper it remains in the ovule, and the latter ripens into a *seed* after its ovum has been fertilised. In lower plants the fertilised ovum develops into a new plant by continuous growth; in Spermaphytes there is a resting period when the seed is ripe, and growth does not continue until the seed is placed under suitable conditions; given these, it *germinates* or sprouts and the growth into a new plant continues. Most plants are incapable of movement in their ordinary condition and must live out their life upon the spot where they began it. It is not however advantageous that the offspring should commence life in the immediate shadow of the parent, and at one period of the life-history, every plant is capable of movement from one place to another, occupying so small a bulk that it can be transported by wind or other agency. In the lower forms this 'condensed plant' is the spore, in higher forms the seed. The spore, being of one cell only and thus small and light, is ideally adapted to transport by wind; the seed being necessarily of many cells loses this advantage, but is more suited to withstand unfavourable conditions of climate, temperature, drought, &c. Many seeds have additional mechanical arrangements facilitating transport.

The fertilised ovum gives rise to the *embryo* or young plant contained in the seed. This (Fig. 1, p. 37) consists of a short axis, the *hypocotyl*, bearing at its upper end the apical bud of leaves (*plumule*) and one or more seed-leaves or *cotyledons* which do not form part of the bud, but are already comparatively well-developed. At the lower end the hypocotyl bears the *radicle* or apex of the future root, which usually faces and is close to the micropyle of the seed. The embryo-sac with its contained endosperm usually increases at the expense of the nucellus and consumes the whole of the latter tissue. The embryo, meanwhile, treats the endosperm in the same way. The integuments ripen into the *seed-coat* or *testa*. Two cases are to be distinguished in the ripe seed. If the embryo in its growth consumes all the tissue within the seed-coat and comes into uninterrupted contact with it, the seed is *exalbuminous*, or has no endosperm ('*albumen*'), as in Cruciferae, Compositae, Leguminosae, &c. If there is any tissue within the testa not forming part of the embryo, the seed is *albuminous*. The tissue may be endosperm only, as in Ranunculaceae, Liliaceae, &c.; this is the most common case; or it may be *perisperm* (the nucellar tissue, usually increased by subsequent growth), as in Nymphaeaceae, Piperaceae, &c. Usually there is endosperm as well as perisperm, when the latter is present. The seedling must at first depend upon stored food-materials for its growth, until its own vegetative organs are in active order, and so there is always a store of reserves in a seed, either in the embryo (chiefly the cotyledons) or outside it, or both.

Descriptive Terms, &c. The seed is usually mentioned after the fruit in technical descriptions. In form, &c. it may be large or small; spherical, ellipsoidal, &c.; anatropous, amphitropous, &c. like the original ovule. The testa may be smooth, or covered with small or large tubercles, papillae, granules, ribs, &c.; green, brown, or of other colours; thin or thick, woody (as in Bertholletia), with a fleshy outer layer (as in Bixa, Magnolia, Moraea, Cycas, &c.), hooked or winged (see below), or provided with hairs. It is usually firm and tough, allowing very little evaporation of water from the seed. Its outer cells sometimes have mucilaginous walls and swell when wetted, as in Linum, Plantago, Collomia, Brassica, &c.; sometimes there are scales or hairs upon it and these swell, as in many Acanthaceae. This is usually regarded as a mechanism for attaching the seed to favourable spots for germination. The testa is usually marked with a scar, the *hilum*, where the stalk separated from the seed.

Many seeds have an extra coat covering them, which is developed like the original integuments, *i.e.* by a cup-like growth of tissue around the seed from the top of the stalk or rarely from the micropyle. Its development may be studied in fruits of Euonymus. Arillate seeds occur in Taxus, many Commelinaceae, &c., Dilleniaceae, Celastraceae, Sapindaceae, Passiflora, Nymphaeaceae, Myristica, &c. In Euphorbiaceae, &c. the aril remains small and hard and is called a *caruncle*, but usually it is fleshy.

The seed may be albuminous or exalbuminous (above), in the former case with endosperm or perisperm or both; the endosperm may be *starchy*, *farinaceous*, *floury*, or *mealy* (the cells containing starch and when powdered forming a floury dust) as in Triticum, *oily* as in Papaver, Ricinus, &c., *fleshy* as in Berberis, *horny* as in Coffea, *bony* as in Phoenix and Phytelephas, *ruminate* (marked by wavy transverse lines which give it a marbled look) as in Anonaceae, *mucilaginous*, &c.

The embryo (rarely embryos) may be straight, curved, twisted, &c. (and *cf.* Cruciferae). It may have one, two, or several cotyledons (this is an important point in classification), or rarely none, as in Cuscuta, &c.

Mention must be made, lastly, of the *adventitious* embryos of Funkia, Nothoscordum, Alchornea, &c. and of the peculiar cases of Ginkgo, and Gnetum, where the seed 'ripens' before fertilisation; see Part II.

The Fruit. The ovule is usually enclosed in an ovary, or protected by scales as in Coniferae, and these parts are stimulated to further growth by the act of fertilisation, and develope together with the ripening seed, finally forming a covering or protection to it, known as the *fruit*. The fruit may be defined as 'the product of that process of growth which is initiated by the act of fertilisation.' This of course includes the seed, and in Cycas, Taxus, &c. fruit and seed are the same. Usually, however, the seed is enclosed in an envelope or *pericarp*, developed from the gynœceum, &c. Many writers lay stress on the difference between *true* fruits and *false* fruits (*pseudocarps*), the former being defined as the product of the ovary only, the latter as the product of the ovary together with any other organ that developes, such as the axis (as in apple or rose) or perianth. The terms, however, are inconsistently used, and are better avoided.

Other changes often occur in the change of an ovary to a fruit; a very common one is the suppression of some (or all but one) of the loculi or the seeds, *e.g.* in oak, Betulaceae, &c. The calyx (or bracts) often persist and surround the fruit (*cf.* Physalis, Fagaceae, Corylaceae, &c.).

Fruits may be divided first of all into *simple*, *aggregate*, and *multiple*. Where a flower gives one indivisible fruit, the fruit is simple, as in cherry or oak; where it gives several similar fruits, independent of one another, as in raspberry, buttercup, Ochna, &c. the fruit is aggregate; where several flowers combine to give one fruit, as in mulberry, fig, plane, the fruit is multiple (or *collective*). In description, mention is made of the multiple or aggregate nature of the fruit and then one of the units is described as if it were a simple fruit.

Fruits may be *dry* or *fleshy*; they may open to allow the seeds to escape (*i.e.* may be *dehiscent*) or may remain closed (*indehiscent*). Indehiscent dry fruits are usually one-seeded; it would be a disadvantage to have many seeds germinating near together. Fleshy fruits rarely dehisce; they are eaten by animals and the seeds are thus separated. Some dry fruits, termed *schizocarps*, break up into one-seeded portions, or *mericarps*, usually corresponding to the individual carpels.

Fruits usually only open in dry air, and remain closed, protecting the seeds, in moist air. Exceptions occur in xerophytes (Chap. III.), where protection is rather needed against drought. Colchicum and other autumnal plants protect their fruit during the winter by keeping it below the soil. In Arachis, Voandzeia, Trigonella sp., Amphicarpaea, Cardamine sp., &c., the (*geocarpic*) plant produces subterranean fruits, either from subterranean or subaerial flowers. In Erodium, Stipa, &c., the fruit has a self-burying mechanism. Reference may also be made to Linaria, Cyclamen, &c. The fruit of Anthemis sp. has an outer mucilaginous layer, like that of many seeds.

Classification, *Descriptive Terms*, *&c.* Dry indehiscent fruits are divided into two main groups, *achenes* and *nuts*. The achene is usually defined as the product of one carpel, the nut as that of more than one, but in practice all small seed-like one-seeded dry indehiscent fruits are achenes, all large ones nuts. True achenes are found in Ranunculus, Potentilla, &c. but the name is also given to the fruit of Compositae, Gramineae (this variety, with pericarp and testa united, is sometimes called a *caryopsis*), Labiatae, &c. True nuts, from superior ovaries, occur in Betulaceae, but the term is applied to the large one-carpelled fruit of Anacardium, &c. A variety of achene or nut is the winged one-seeded indehiscent *samara* of ash, elm, Banisteria, Liriodendron, Ptelea, Ventilago, Seguieria, &c.

Schizocarps are of various kinds, *e.g.* the *lomentum* of many Leguminosae (a pod that is constricted between the seeds and breaks into one-seeded portions), the schizocarps of Euphorbiaceae, Geraniaceae, Malpighiaceae, Umbelliferae, many Malvaceae, and Sapindaceae, &c. (see Part II.).

Dry dehiscent fruits are of several kinds; the most common are the *follicle*, *legume*, and *capsule*. The follicle consists of one carpel, and dehisces along the ventral side only, as in Aconitum, Asclepiadaceae, Apocynaceae, Crassulaceae. The legume is similar but dehisces along both sides, as in most Leguminosae, *e.g.* a pea-pod. All dry fruits of more than one carpel are grouped under the general name of capsule, but special forms have special names, *e.g.* the pod-like *siliqua* of Cruciferae, the *pyxis* of Anagallis, &c. (capsule opening by a lid split off by *circumscissile* dehiscence), and others. The way in which the capsule dehisces is of systematic importance. The general method is by splitting from the apex downwards. If the splits, as in Iris, Epilobium, &c., run down the midrib of each carpel, the dehiscence is *loculicidal*: if, as in Hypericum, the fruit breaks into its component carpels, leaving the placental axis standing, it is *septicidal*; if the outer wall of the fruit breaks away, leaving the septa standing, it is *septifragal*. The portions into which the fruit splits are termed *valves*. In Papaver, some Campanulas, &c., the dehiscence is *porous*, little openings forming in the pericarp.

The commonest fleshy fruits are the *berry* and *drupe*. The former contains no hard part but the seeds; these are surrounded by fleshy tissue and there is a firmer skin (*epicarp*) on the outside. Berries may be derived from superior ovaries, as in Berberis, Vitis, Solanum, &c. or from inferior, as in Ribes, Vaccinium, &c. In rare cases the berry dehisces, as in Myristica and Akebia, or is constricted between the seeds, as in Unona and Maerua. The drupe (*e.g.* cherry) has a skin (*epicarp*) on the surface, then a fleshy mass of tissue (*mesocarp*) and a hard shell or stone (*endocarp*), all forming part of the pericarp; within the stone is the seed or kernel, usually without a hard coat. Drupes from superior ovaries occur in Prunus, &c., from inferior in Cornaceae, Juglans, &c. There may be one stone or *pyrene* (Prunus) or several (Cornus).

Other fleshy fruits are the *pome* of Pyrus, &c. in which the fleshy receptacle encloses, and is united to, the core or product of the gynœceum proper; the *pepo* or gourd of Cucurbitaceae, *e.g.* cucumber (a variety of the berry with hard epicarp), the peculiar pseudo-berry of Juniperus (*q.v.*), &c., the fruit of strawberry (large fleshy receptacle bearing achenes), rose (fleshy receptacle enclosing achenes), Anacardium (fleshy receptacle bearing a nut), Gaultheria (a capsule enclosed in the fleshy calyx), Urera, &c. (achene in fleshy perianth), and so on.

Aggregate fleshy fruits occur in Rubus (drupes), Anonaceae (berries), &c. Multiple fleshy fruits are frequent in Moraceae (*e.g.* mulberry, fig, bread-fruit), Ananas, Carludovica, Anona, &c.

The style and stigma often fall away as the fruit ripens, but frequently remain in a more or less shrivelled or in an enlarged condition. Sometimes the style forms a hook, as in Geum, a plume, as in Clematis, or an *awn*, as in Geraniaceae (this name is applied to any long thread-like organ on a fruit; *cf.* Gramineae).

Other interesting morphological features in fruits are mentioned below and in Part II.; besides the families and genera mentioned see Aesculus, Bertholletia, Chenopodium, Leontodon, Nymphaeaceae, Nyctaginaceae, Palmae (*e.g.* Phytelephas, Lodoicea, &c.), Pandanaceae, &c.

Distribution of Seeds to a distance from the parent plant is of importance in two ways. It helps us to understand many questions in the geographical distribution of plants, such as the planting of oceanic islands, the presence of stray plants from one flora in the midst of an alien flora, and so on, and it is a very important factor in the life-history of an individual plant or species. It is evidently advantageous that the seeds should be carried to a little distance from the parent plant and from one another, so as to avoid shading and excessive competition. From the first consideration it behoves us to examine all *occasional* means by which seeds can by any possibility be dispersed. To the individual, on the other hand, only *regular* means of transport, taking place by aid of special mechanisms in the seed or plant itself, are of importance.

One great obstacle to migration is a wide extent of ocean. Many seeds however are able to withstand sea-water for sufficient periods to be carried long distances. Trunks of trees may be floated away, carrying earth and seeds with them. Numbers of seeds, capable of germination, are brought by the Gulf Stream from the West Indies to Europe. Floating ice, especially river-ice, may also carry seeds. Tornados frequently carry seeds, &c. to great distances, though they may not be adapted to ordinary wind-carriage. The balls of mud on the feet of water-birds, partridges, &c., often contain seeds in good condition. Carnivorous birds sometimes swallow their prey and afterwards void the contents of their crops, containing seeds capable of germination. Locusts carry grass-seeds with them, and so on (see *Origin of Species*, Chap. XII.).

In the regular methods of seed-dispersal, we find four agents that may be employed—wind, water, animals, and propulsive mechanisms upon the parent plant itself.

The unicellular spores of ferns, &c. float in the air like dust. The nearest approach to this in seed-plants is in the Orchidaceae, whose seeds are extremely small and light. Pyrola and many Caryophyllaceae, &c. have also very light seeds. A number of plants with dry fruits have what may be termed 'censer' mechanisms. The fruit opens so far as to leave the seeds room to escape, but in such a way that they can only escape when the fruit is violently shaken, *i.e.* as a rule, only when a strong wind is blowing; thus they have a good chance of being carried some distance. Such fruits are the capsules of most Liliaceae, Iridaceae, Caryophyllaceae, &c., the fruits of Aconitum, Helianthus, &c. The seeds are liable to damage from rain in an open fruit of this kind; some close when it rains, others only open by narrow protected openings, *e.g.* Papaver, Campanula. In Tulipa, Iris, &c., the seeds are flattened, thus increasing the surface exposed to the air without increasing their weight. In Pinus, Deutzia, Gordonia, Zanonia, Millingtonia, &c., the seed is winged as well as more or less flattened, and may be carried to some distance before reaching the ground. In Fraxinus, Liriodendron, Acer, many Malpighiaceae, Serjania, Seguieria, Ptelea, Ulmus, Paliurus, Ventilago, Abronia, Tripteris, Terminalia, Pterocarpus, Centrolobium, &c., the wings are on the fruit, outgrowths of the pericarp. In Bougainvillea, Spinacia, Mirabilis, Carpinus, &c., the bracts or bracteoles form the wings, in Triplaris, Armeria, Davilla, Rumex, Dipterocarpaceae, Trifolium sp., &c., the perianth, or part of it. In *Rhus Cotinus*, Spinifex, &c., the fruit-head is rolled bodily about by the wind (*cf.* Selaginella sp., Anastatica). A great number of seeds and fruits exhibit very perfect 'parachute' mechanisms in the form of tufts or coverings of hairs, *e.g.* the seeds of Salix, Gossypium, Epilobium, many Apocynaceae and Asclepiadaceae, Aeschynanthus, &c.; the achene fruits of Eriophorum, Typha, Anemone, Compositae, &c.; in Clematis the style becomes hairy after fertilisation.

Adaptations to water-carriage are found in a few water-plants (Chap. III.), and in Veronica sp., &c.

Animal distribution is of two kinds—inside or outside the animal. To the former class belong all fleshy fruits; these are eaten and the seeds afterwards dropped. The seeds must be able to pass uninjured through the alimentary canal. This is usually effected by means of a hard covering, the seed-coat in berries, the endocarp in drupes. In some cases the seed is sticky, *e.g.* in Viscum, and is ejected by the bird; in Strychnos, &c., it is poisonous. Most fleshy fruits are distributed by birds and are found on shrubs and trees; comparatively few are eaten by other animals. They are commonly brightly coloured when ripe, and so attract notice (*cf.* flowers). In Anthurium, Magnolia, Acacia sp., &c., special arrangements increasing the conspicuousness are found. The seeds of Abrus, Adenanthera, Ricinus, &c., and the fruits of Scorpiurus, Biserrula, &c., resemble beetles or caterpillars, and it is often suggested that birds are deceived by them and carry them to a distance before finding out the mistake. Carriage of seeds or fruits by the outer surface of the animal's body is usually effected by hooks. Hooked seeds are very rare; they occur in Villarsia, &c. Hooked fruits (burs) are common; the hooks may be on any part of the fruit proper or on the accessory organs—receptacle, corolla, &c. (*e.g. cf.* Bidens, Tragoceros, and Xanthium, in Compositae). Examples are Triglochin, Uncinia, Cenchrus, Emex, Triumfetta, Bunias, Agrimonia, Acaena, Geum, Medicago, Circaea, Blumenbachia, Sanicula, Daucus, Galium, Asperula, Cynoglossum, Martynia, Harpagophytum, &c. In Tribulus, &c., the fruit has hard spines and lies upon the soil till trodden on by an animal and is then carried away sticking in its foot. In Arctium the hooks cling to passing animals and finally let go their hold and the plant swings back jerking out the fruits. In Allionia, Pisonia, Plumbago, Siegesbeckia, &c., the fruit clings to animals by means of glandular hairs.

Propulsive mechanisms in the fruit itself may be of two kinds. In Dorstenia, Oxalis, Impatiens, Cyclanthera, Ecballium, &c., the propulsion depends upon extreme turgidity in some part of the fruit. In Lupinus, Ulex, Eschscholtzia, Scandix, Euphorbia, Ricinus, Hura, Acanthaceae, Alstroemeria, Cardamine, Buxus, Claytonia, Viola, Geranium, &c., tensions are set up by the drying of certain parts of the fruit-tissue when exposed to the air.

Observation shows that as a rule none of the mechanisms transport seeds or fruits to great distances; a few hundred yards is usually the maximum. This, however, is probably sufficient to gain all the advantages of seed-dispersal.

In studying the mechanisms of seed-dispersal, the morphology of the various fruits should be compared, so as to notice how in different fruits the same end is attained in different ways; *e.g.* how the testa, aril, gynœceum wall, receptacle, corolla or perianth may be fleshy, or hooked, &c. It should also be noted that there is much greater variety in this respect among nearly allied forms than there is in the general floral mechanism. This goes to show that the seed-dispersal methods are of recent acquirement. Such orders as Cruciferae, Compositae, Leguminosae, Rosaceae, Umbelliferae, and such genera as Trifolium, Valerianella, &c., are of special interest in this connection. Further details will be found in Part II., and in Chap. III. (especially see under Epiphytes)[1].

Germination. Placed under suitable conditions—darkness, moisture, supply of oxygen, and suitable temperature—the seed germinates (Fig. 1, p. 37). The testa is burst by the swelling of the seed, the radicle is pushed out, at or near the micropyle, by the lengthening of the hypocotyl, and grows down into the soil as the root. The

[1] Hildebrand, *Verbreitungsmittel der Pflanzen*, Leipzig, 1873; Darwin, *Origin of Species*; Kerner, *Natural History of Plants*. Literature to 1890 indexed by MacLeod in Bot. Jaarb., Gent, 1891.

plumule presently comes above ground, often bent back on itself into a hook-shape, and begins to develope into the young shoot. The cotyledons as a rule come up too, turn green, and act as the first foliage leaves, but if there is any endosperm they first of all act as absorbent organs to take up the reserves it contains. In a few exalbuminous seeds, *e.g.* pea, the cotyledons are so gorged with reserves that by the time they are exhausted the young plant is well enough grown to be independent, and there is no need for them to turn green, nor do they. Such also is the case in a few albuminous seeds, *e.g.* the Gramineae.

Observations made by Detmer[1] on the heights, weights, &c., of plants grown from heavy and light seeds show that, other things being equal, the former are as superior to the latter as the offspring of cross- to that of self-fertilisation, so that this is a very important factor in the life-history. It might pay a plant, so to speak, to give up cross-fertilisation and expend the saving on heavier or more numerous seed. As usual, a balance must be struck between opposing necessities; the heavier the seed the less its chance of distribution.

An interesting point frequently seen in seedlings is the exhibition of transitional stages towards the mature state (p. 29). Good examples are Acacia, Bossiaea, Ulex, Hakea, many succulents, &c.

Vegetative Reproduction. Frequently portions of the vegetative organs, specialised in structure or not, are detached and grow into new plants. The detachment need not precede the growth of the new plant, but may follow it, as in the case of the young strawberry-plants formed upon the runners. It is of interest to notice the various ways in which the young daughter-plants may be nourished. If the detached portion be not green, as *e.g.* a potato tuber, reserve materials must be stored up in it to start its growth and keep it growing until it can assimilate for itself, so that it is the physiological though not the morphological equivalent of a seed (gardeners speak of 'seed-potatoes'). If the young plant, as *e.g.* in the strawberry, remain in connection with

[1] Detmer, *Keimungsphysiologie*; Lubbock, *Seedlings*; Goebel, *Organography of Plants*; Vandevelde, *De Kieming der Zaadplanten*, in Bot. Jaarb., Gent, 1897 (literature list).

the parent, no reserves are needed, the parent feeding it till it is capable of independent existence.

Vegetative reproduction is certain, effective, and economical; the profusion of such plants as daisies, buttercups, raspberries, hyacinths, is largely due to it. Its chief disadvantage is the loss of the benefits of fertilisation.

It is well-known that in a sense the vegetative and 'true' reproductive activities of a plant are antagonistic (see p. 103). If a plant is growing in rich soil or in the shade, the vegetative activity is favoured, whereas when vegetative growth is checked, the plant tends to flower more. Excessive vegetative activity tends to favour vegetative reproduction at the expense of the sexual method. Vöchting has shown by direct experiment that reduced light favours vegetative multiplication.

It is rare for the root to give rise to a shoot; vegetative reproduction generally consists in the detachment of a shoot-structure, with or without roots. It is almost confined to herbaceous plants; comparatively few trees are thus propagated.

The simple detachment of a branch, not in any way modified in structure, is common in water-plants, and in plants with rhizomes. Special branches for vegetative propagation are the runners of Fragaria, Ranunculus, Agropyron, Ajuga, Nephrolepis, &c., the suckers of Gesneriaceae, Epilobium, Rubus, Agave, Sempervivum, Salicaceae, &c. Bulbs, corms, tubers, &c. (Chap. III.) all lend themselves readily to this mode of propagation. Similar structures appear above ground in many plants, and are then primarily reproductive; such are the *bulbils* or little bulbs of Lycopodium, Agave, Lilium, Allium, Remusatia, Gagea, Dentaria, Oxalis, &c., which usually appear in place of flowers, in the inflorescence, the tubers of Begonia, Globba, Polygonum, &c., the young plants that appear by budding of tissues in Asplenium, Cardamine, Bertolonia, Begonia, Rubus, Chlorophytum, Crassula, Sinningia, &c.

The disadvantageous tendency in vegetative multiplication is that the offspring shall be so closely crowded together as to cause a severe competition between themselves and between them and the parent. To avoid this danger there are several methods, as seen in seed-reproduction. In water-plants the detached branches or buds are carried away by the water. Many detached parts are carried off by birds for nest-making, *e.g.* in *Tillandsia usneoides;* others have arrangements for adhering to animals, *e.g.* the hooked bulbils of Remusatia, the branches of Mammillaria, &c. The nodes of Panicum and other grasses pass through the alimentary canals of animals and subsequently germinate. The tubers of *Senecio articulata* may be rolled along the ground by the wind, like the plants of *Selaginella lepidophylla*. The bulbils that are so frequent in inflorescences may be jerked to a distance when the plant is shaken. In reproduction by suckers, runners, or similar methods, the length of these is usually sufficient to ensure separation.

Appendix. Hairs, Emergences, Latex, &c. A few minor anatomical features remain to be mentioned, as they are of importance in classification, natural history, &c.

Hairs are cellular outgrowths from the epidermal tissue, branched or unbranched, of the most various shapes, and are exceedingly common on all parts of plants (for descriptive terms see p. 53). Their use is often doubtful. The dense hairy covering of many xerophytes checks transpiration, the stinging hairs of Urticaceae, Loasaceae, &c. are protective, the barbed hairs of the fruits of Galium, Blumenbachia, &c. serve for animal distribution, and so on.

Emergences are outgrowths of the surface which arise from other tissues as well as the epidermis, *e.g.* the tentacles of Drosera, which contain vascular bundles, the prickles of Rosa and Ribes, and other such outgrowths.

Latex is a milky fluid, usually white or yellow, contained in special *laticiferous vessels* or *cells* which run through the tissues of certain plants, *e.g.* Euphorbia, Cichorieae (Compositae), many Papaveraceae, Apocynaceae, Asclepiadaceae, Sapotaceae, &c. The fluid contains substances of various kinds; some are of use in the nutrition of the plant, and to some extent the laticiferous tissue therefore replaces the phloem; others, *e.g.* caoutchouc, are apparently excretory products of little or no use to the plant.

Raphides are needle-shaped crystals of calcium oxalate, contained in the cells, especially in young growing parts and in Monocotyledons. The painful effects of chewing a piece of the leaf of *Arum maculatum* are due to the raphides sticking into the mucous membrane.

Water-pores or *hydathodes* are openings, resembling stomata, upon leaves or elsewhere, through which the plant excretes water, often containing other substances, *e.g.* chalk, in solution. During the day evaporation carries off the water, but at night it often accumulates and is generally mistaken for dew. The drops of water so commonly seen in the morning on the tips of grass blades have been thus formed. Water-pores are also found in many species of Saxifraga, Tropaeolum, Fuchsia, Caladium, &c. When the water contains sugar in solution, a nectary (p. 88) is formed[1]. These are usually in flowers, but there are many cases of *extra-floral* nectaries, *e.g.* on the leaves of the cherry-laurel (Prunus), stipules of Vicia, Viola, &c. Extra-floral nectaries usually attract ants in large numbers, and this brings to the plant a certain advantage by keeping off caterpillars, &c. Several tropical plants show extreme cases of adaptation in this direction, by housing and feeding

[1] Usually there is no pore in a nectary, the fluid being excreted by the superficial cells.

standing armies of fighting ants. Such plants are said to be *myrmecophilous* (see Acacia, Cecropia, &c.). In this connection mention may be made of the *honey-dew* so common on leaves (see Acer, Pithecolobium, &c.), and of the *domatia* or little dwellings inhabited by mites, usually constructed of hairs, or sometimes in little hollows or grooves of the leaf (see Fraxinus, Anamirta).

Resin-passages are large canal-like intercellular spaces in the tissues of certain plants, *e.g.* Coniferae. Into them the plant secretes resin; this appears to be a waste-product, though it may have an incidental value in protecting the wood from decay, or in other ways.

Oil-cavities containing oils of various sorts, are frequent in various plants, especially in the leaves, where they show as translucent dots when held up to the light. They occur in Rutaceae, Guttiferae, &c.

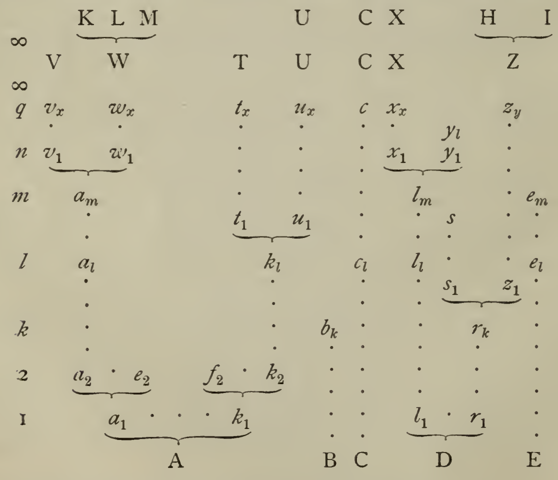
Glands are organs secreting fluids upon the surface of a plant (or sometimes internally). Water-pores and nectaries may be included under this head, and other glands secrete oils, &c.

CHAPTER II.

CLASSIFICATION OF PLANTS.

CLASSIFICATION of plants, like that of their organs, is based upon phylogeny, itself investigated by the comparative method described in Chap. I. We have seen (pp. 21—25) that accumulation of variations leads to the modification of organs; we may now go a stage further and apply it to species.

Evolution[1]. The diagram here given is intended to roughly illustrate the origin of new forms from pre-existing



[1] See works mentioned in footnote to p. 23.

forms by aid of natural selection of continuous variations. Let us suppose that at a certain period there are five species, represented by the letters A to E, living in a given region, and that A and D are represented by many, B, C, and E by few, individuals. Take first the case of A. The offspring of the various individuals will form a large number, represented by the letters $a_1 \ldots k_1$. They will vary in their characters. Suppose a_1 to represent those individuals which possess in the most marked degree a certain character or (more usually) sum of characters which in the struggle for existence will be advantageous to them. Suppose k_1 to represent another group possessing in a high degree some other beneficial character; the intermediate groups possess these characters in a less marked degree. Then, in the struggle for existence, the tendency will be for the groups a_1 and k_1 to defeat the intermediate groups and *also the parent form*. Probably the groups a_1 k_1 will not be the only survivors, but they will produce most offspring. In the next generation the offspring will again vary in the same characters and those that vary furthest in favourable directions, *i.e.* the groups a_2 k_2, will tend to produce most offspring. The same process may be repeated in every generation, and thus the original species will give rise to steadily *diverging* lines of offspring (the divergence is not shown in the diagram beyond the second generation). After many generations, the differences between the group *a* and the group *k*, at first infinitesimal, will become obvious, and we may now say that the species A has two *varieties*, *a* and *k*. The type form A itself will perhaps usually have ceased to exist in this locality, but if one of the varieties to which it has given rise be much commoner than the others, naturalists generally, though incorrectly, term this the 'type' of the species, unless, as probably often happens, the new variety or varieties have arisen on the margin of the area of the earth's surface occupied by the parent species, which may then continue to exist side by side with the variety.

Varieties are common in most of the larger genera and species, *e.g.* Rosa, Rubus, Hieracium, Salix. They differ from one another chiefly in small and variable characters, especially of the vegetative organs; *e.g.* there are two varieties of the common buttercup (*Ranunculus acris*), one of which, var. *Steveni* Reich., has the stem slightly hairy at the base and the segments of the radical leaves not overlapping; while the other, var. *vulgatus* Jord., has the stem densely hairy at the base and the leaf-segments overlapping. The student should work through Hooker's *British Flora* and note the divergences of character usually considered as sufficient to mark varieties. He can hardly fail to be struck by the apparently trivial nature of the differences, and will often be at a loss to understand what value they can possess in the struggle for existence. This point cannot be discussed here; we can only refer to what has been said above as to the possible value of any variation, and as to correlated variation. On the theory of mutation, varieties or "elementary species" may arise at one step, and it is perhaps somewhat less difficult to account for varietal characters being so often of no apparent value to the plants.

It is by no means easy to decide when two forms are sufficiently separated to be ranked as varieties; it is essential that in several characters their variation should be discontinuous, yielding a two-humped curve (p. 22), though in actual systematic practice this criterion of definite measurement is seldom employed; examination of a large number of specimens is usually sufficient to enable a judgment to be formed as to the continuity or discontinuity of the variation of the characters.

To return to the diagram, imagine the original species A now represented by the two varieties a_l and k_l. The latter may diverge again into two new varieties, t and u, and afterwards a into v and w, and at the stage marked by q the species will thus have four varieties. The differences between v and w will be slight, most of their characters being the same as those of the parent form a; t and u will be rather more widely separated in character. The differences between the two pairs, on the other hand, will be considerable, as they are separated by so many generations from the common ancestor A.

The divergence of the four varieties continuing, will ultimately become so considerable that the forms must be ranked as *species*. To define exactly what is meant by this term is as yet impossible. Most of the great systematists, *e.g.* Sir Joseph Hooker, use rather comprehensive species, often including many varieties; such species are now often called "Linnean species," in contradistinction to the elementary or "Jordan's species," which are considered as varieties by Hooker. Botanists who work mainly at the flora of a limited region, or at single groups of plants, usually tend to make small species. The balance of opinion at present favours the use of large species, and this course is followed in the present work, and in the vast majority of botanical books. The student will find it of interest in this connection to study such genera as Rubus, Salix, Hieracium, &c. with the different British Floras of Hooker, Bentham, Babington, &c.

Two nearly allied species will have many characters in common derived from the common ancestor, but will show more differences, and those more clearly marked, than varieties. The latter when crossed usually yield fertile offspring, whereas the offspring (*hybrids*) of two species are usually comparatively sterile (but *cf.* the case of heterostyled flowers, p. 95). The student should work at the determination of species until familiar with the kind of characters that mark specific distinction; he will note that they are chiefly characters of the vegetative organs, and minor characters of flowers, fruits, &c.

The original species A has thus, after a considerable lapse of time, given rise to four new species, T, U, V, W, by which it is now represented on the earth. Now consider the case of B, a species nearly allied to A and represented by few individuals. The chance of a favourable variation appearing in a number of the offspring is smaller; let us suppose that none appears, and that B continues unchanged, until the general ecological conditions change, or an unfavourable variation occurs, or other forms come into closer competition with it. It may then gradually dwindle in numbers and finally die out. Extinction of species is a common occurrence, as geology teaches. Now take the case of C, also a species of few individuals. This we may suppose not to become extinct during the period under consideration, because it has had a favourable situation, little competition, a very peculiar mode of life, or some other advantage. It therefore appears in the top line, representing the later period. D is supposed to be a species with many individuals, and therefore one in which favourable variations are more likely to arise. It gives rise to four varieties, but ultimately only to two species, X and Z. E is supposed to die out like B.

The four species T, U, V, W are nearly allied. After a long period they will again give rise to new species, represented by the letters in the top row. The species K, L, M derived from W will be nearly allied in character, but will differ much from U and still more from C, from X, and from the two species H and I (derived from Z). The divergence between these various groups will now be so great that they will be regarded as *genera*, one with three species, one with two, and the rest each with one species. The common ancestor of the species of a genus is far back, but the common ancestor of two allied genera farther still. Genera agree in fewer characters than do species. The characters that mark genera should be studied in a flora (see also Coniferae in Pt. II.); it will be noticed that floral characters enter more largely into the diagnoses than in the case of species. The genus represented by the one species C will be what is called an *archaic* genus, a type belonging to a former age. Several examples of this kind may be met with, *e.g.* Casuarina, Isoetes, Phylloglossum, &c.

Just as varieties gradually diverge into species and these into genera, so these again form groups of genera, or *natural orders*. The characters of all the natural orders are given in full in Part II. and should be studied there, especially by the method of comparison of allied orders. The orders may be grouped into *cohorts*, these into *series*, and so on.

It is necessary to keep clearly in mind the fact that the ancestral forms die out as species diverge, and can only be found, if at all, as fossils. The archaic forms of vegetation now existing are of special interest as types of a preexisting flora, but they must not be regarded as representing the ancestral forms from which our existing vegetation of higher types is derived, though very possibly often nearly related to them. The study of fossil botany has brought to light many interesting relics of past vegetation, but probably few, if any, of these are direct ancestors of now existing forms. Those plants which are of woody nature are most likely to be preserved, while the general upward evolution to the highest flowering plants appears to have taken place chiefly in herbaceous plants. In these, generation succeeds generation rapidly, and thus evolution can go on more quickly than in trees or shrubs.

Principles of Classification. On the theory of descent, the vegetable kingdom may be represented by a tree, the existing species being the tips of the branches, and the older parts of the stems representing forms now extinct. Plants then can be arranged in groups under groups. Species are grouped into genera, these into orders, and so on. If our museums of fossils could supply us with all the forms of vegetable life that have existed on the earth classification would be an easy task. As it is, however, we possess only the tips of the twigs, so to speak, and have to reconstruct the tree and fit them into their proper places on it. This is done by careful and detailed comparison of all the characters of the various organisms; those which agree in a large number of characters are considered as nearly related, those which agree in few as more distantly related, to one another. The ideal to be aimed at in classification is a systematic arrangement of all known forms, existing or fossil, to show their mutual relationships, and grouped into genera, orders, &c. An ordinary written scheme of classification can never completely fulfil this object, for it endeavours to represent on a plane surface what can only be accurately shown in the solid.

Plants show, as we have seen, varying degrees of resemblance, or *affinities*; Darwin first showed that affinity meant relationship. The *natural* system of classification, which tries to group plants according to their affinities, was already well advanced before 1859, and has since been brought nearer to perfection, though there is yet a very great deal of work to be done.

A classification which only takes account of a few characters is found not to show relationships truly; such is the famous *artificial* system of Linnæus, a convenient arrangement for practical use, but now superseded by the natural system. We must always work with the *aggregate* of characters of every species; this is easily understood after what we have said above. Very often, indeed, a single character or combination of characters enables us to recognise the approximate relationship of a species very easily, but its exact relationship can only be determined by a study of all its characters.

The larger the aggregate of characters we can use the more certain the results. There is good reason to believe that polyphyly (p. 29) is extremely common in the evolution of plants; if we use one character only as a diagnostic we shall be certain often to go astray in this respect (cf. remarks on adaptation, p. 25), and even it is probable that at times several distinct characters may be correlated and accompany one another, but if we use large aggregates of characters we shall usually be comparatively safe.

Careful and extensive comparison of characters is then the method mainly in use for determining the relationships and phylogeny of plants. The remarks on p. 27 should be carefully read in this connection. A character which is nearly uniform and common to a large number of species is regarded as of high importance, it being, upon the theory of descent, one which has been handed down unaltered from very ancient times. It may thus be used as a diagnostic character of a large group, but it must always be remembered that unless it is usually accompanied by other widely spread characters, we may be dealing with a case of polyphyly. To take a concrete instance, Angiosperms are divided into two groups mainly upon the possession of one or two cotyledons, but these characters are usually accompanied by others of almost equal persistence, such as the "scattered" vascular bundles of Monocotyledons. Characters of more inconstant nature, and common to fewer species mark smaller groups, and so on. But there must always be a considerable individual equation in the definition of groups of plants, because one individual will regard one character, another another, as of more importance in doubtful cases.

Now consider the kind of characters used. "The less any part of the organism is concerned with special habits the more important it is for classification." Such a part will be less liable to rapid variation and modification. The vegetative organs, therefore, are comparatively useless in diagnosing the larger groups. There are, however, vegetative characters which are not so liable to modification and are therefore useful; such are the alternate or opposite arrangement of the leaves, their veining, &c. The embryonic characters of the vegetative organs, *e.g.* the number of cotyledons, are very important. Vestigial organs are often of great importance in classification. The characters of flower and fruit are the most important for diagnosis of large groups. It is necessary to recognise, however, the kind of floral character to use. We have seen (p. 70) the importance of cohesion of parts. Once acquired, it is not likely to be lost and may be handed down to a large number of descendants; the amount of cohesion, on the other hand, is a very variable character. In the same way, the existence or non-existence of adhesion, the shape of the receptacle, irregularity, number of members in a whorl, introrse or extrorse opening of anthers, &c. are all important. The characters of the gynœceum are very useful, *e.g.* the placentation, the position of the raphe of the ovule, the anatropy, &c. of the ovules, and so on. The number of cotyledons, the shape of the embryo, and the presence or absence of endosperm in the seed, are also good characters. All these are largely used for the diagnosis of the larger groups, as will be seen by a study of the tables below and of the characters of the orders in Part II. The characters of vegetative organs and the more easily modified floral characters are chiefly used in the diagnosis of genera and species.

A very important point to recognise is this, that a given character may be good in one group of plants, and in another may be nearly useless and exhibit a great deal of variation; this is easily understood on the theory of descent. For example, whether a flower is perigynous, epigynous or hypogynous is usually an important character, used in diagnosing natural orders, but in the genus Saxifraga all three conditions may be found. Other illustrations are Nigella in Ranunculaceae with its syncarpous gynœceum, Vaccinium in Ericaceae, and so one.

Systems of Classification. It is evident that in any written system of classification there must be a considerable element of artificial grouping. For practical purposes this matters little, and when once a system has been adopted for use it is well to adhere to it; in large herbaria, for example, it is impossible to make frequent changes of arrangement to suit the progress of knowledge. Students should be trained in the system which offers the closest approach to the representation of the knowledge of the day. The system of Bentham and Hooker, proposed in their *Genera Plantarum*, has remained the standard one in Britain for a long time, but on the Continent has long been superseded by the more natural system based on that of Brongniart. The latest exposition of this system is that of Engler in the *Syllabus der Vorlesungen*, and in *Die natürlichen Pflanzenfamilien*. We have therefore adopted this system for the flowering plants, but a key is also given to the system of Bentham and Hooker, so that those who prefer may use the latter. The natural orders given in Part II. are those of Engler, but their place in the other systems is always indicated. A third system, outlined below, is that of Eichler, adopted by Warming (*Systematic Botany*, English ed.); it resembles that of Engler very closely. The ferns and their allies are classified according to the most recent views upon the subject.

The Vegetable Kingdom is primarily divided into four groups:

Thallophyta—Algae and Fungi.

Bryophyta—Mosses and Liverworts.

Pteridophyta or Vascular Cryptogams—Ferns, Lycopods, Equisetums, &c.

Spermaphyta or Phanerogams—Seed-plants or so-called flowering plants (see Part II.).

With the first two groups we are not concerned in this work. The classification of the Ferns, &c. is given in Part II. (art. Pteridophyta, &c.). We shall deal here with the last and highest group.

The primary division of the Spermaphytes in all systems is into Gymnosperms and Angiosperms, but it is probable that this is very artificial—that the former are really three classes derived from separate stocks of the early Pteridophyta, and the latter really two or more classes derived possibly from primitive Gymnosperms. The Angiosperms are divided into Mono- and Di-cotyledons in all systems, but the further subdivisions vary. The outline given below gives the characters of these groups as far as the cohorts; the characters of the orders must be sought in Part II.

SYSTEM OF ENGLER, 1892—96.

SPERMAPHYTA.

GYMNOSPERMAE.

(Ovules before pollination not enclosed in an ovary formed of infolded or united carpels; endosperm formed before fertilisation; see G. in Pt. II.)

Class I. Cycadales (stem with little or no branching; leaves pinnately divided, forming a rosette at end of stem; flrs. diœcious, not massed in infl.; no perianth):
N. O. 1. Cycadaceae.

Class II. Coniferae (stem branched; leaves usually narrow, often linear; flrs. unisexual; no perianth):
N. O. 2. Araucariaceae. 3. Taxaceae.

Class III. Gnetales (stem simple or branched; leaves in pairs, undivided; flrs. unisexual or ☿, with perianth, and more or less enclosed in bracts):
N. O. 4. Gnetaceae.

ANGIOSPERMAE.

(Ovules produced in an ovary formed of coherent carpels or of one carpel with coherent margins; endosperm formed after fertilisation; see A. and Chalazogamae in Pt. II.)

Class I. Monocotyledones (embryo with one cotyledon; stem with closed vascular bundles, 'scattered' as seen in cross-section; leaves usually parallel-veined; flrs. usually 3-merous; see M. in Pt. II.):
Cohort 1. *Pandanales* (flr. naked or with homochlam., bract-like perianth, unisexual; sta. 1—∞; cpls. 1—∞; endosperm; infl. compound, spherical or cylindrical):
N. O. 5. Typhaceae. 6. Pandanaceae. 7. Sparganiaceae.

Cohort 2. *Helobieae* (flr. cyclic or hemi-cyclic; perianth o or in 1 or 2 whorls, homo- or hetero-chlam., hypogynous or epigynous; sta. 1—∞; cpls. 1—∞, apo- or syn-carpous; endosperm little or none; water or marsh plants or saprophytes):

N. O. 8. Potamogetonaceae. 9. Naiadaceae. 10. Aponogetonaceae. 11. Juncaginaceae. 12. Alismaceae. 13. Butomaceae. 14. Triuridaceae. 15. Hydrocharitaceae.

Cohort 3. *Glumiflorae* (flr. naked, rarely with hair-like or true perianth, covered by glumes; ovary 1-loc. with 1 ovule):

N. O. 16. Gramineae. 17. Cyperaceae.

Cohort 4. *Principes* (flr. usually cyclic, homochlam., 3-merous, hypogynous, regular or rarely zygomorphic; cpls. 3, usually each with 1 fleshy ovule; stem monopodial with fan-like or pinnate leaves; infl. a simple or compound spadix):

N. O. 18. Palmae.

Cohort 5. *Synanthae* (flr. always unisexual; ♂ naked or with thick shortly-toothed perianth and 6—∞ sta.; ♀ naked or with 4 fleshy scale-like leaves, before each of which is a long thread-like staminode; cpls. (2) or (4), with 2 or 4 placentae, and ∞ ovules, sunk in axis of spadix):

N. O. 19. Cyclanthaceae.

Cohort 6. *Spathiflorae* (flr. cyclic, with o, 1, or 2 whorls of perianth, 3- or 2-merous, ☿ or unisexual, often much reduced, even to 1 sta. or cpl.; spadices simple, enclosed in spathes, with no bracts; sympodial plants, rarely with well-developed stems):

N.O. 20. Araceae. 21. Lemnaceae.

Cohort 7. *Farinosae* (flr. homo- or hetero-chlam., 3- or 2-merous, usually P 3 + 3, A 3 + 3, G (3); one whorl of sta. is sometimes wanting, or all sta. but 1; ovules often orthotropous; endosperm mealy):

N.O. 22. Flagellariaceae. 23. Restionaceae. 24. Centrolepidaceae. 25. Mayacaceae. 26. Xyridaceae. 27. Eriocaulaceae. 28. Rapateaceae. 29. Bromeliaceae. 30. Commelinaceae. 31. Pontederiaceae. 32. Philydraceae.

Cohort 8. *Liliiflorae* (like 7, but endosperm fleshy or cartilaginous; ovules usually anatropous; flrs. sometimes 4- or 5-merous):

N.O. 33. Juncaceae. 34. Stemonaceae. 35. Liliaceae. 36. Haemodoraceae. 37. Amaryllidaceae. 38. Velloziaceae. 39. Taccaceae. 40. Dioscoreaceae. 41. Iridaceae.

Cohort 9. *Scitamineae* (flr. cyclic, homo- or hetero-chlam., 3-merous, typically diplostemonous but often with reduction of andrœceum even to 1 sta., usually epigynous and zygomorphic; ovary usually 3-loc. with large ovules; seeds usually with arils and with endo- and peri-sperm; tropical plants):

N.O. 42. Musaceae. 43. Zingiberaceae. 44. Cannaceae. 45. Marantaceae.

Cohort 10. *Microspermae* (flr. cyclic, homo- or hetero-chlam., typically diplostemonous but often with important reduction; ovary inferior, 3- or 1-loc. with ∞ small ovules; endosperm or none):

N. O. 46. Burmanniaceae. 47. Orchidaceae.

Class II. Dicotyledones (embryo with two cotyledons; stem with open vascular bundles usually in a single ring; leaf net-veined; flr. usually 5-, 4- or 2-merous; see D. in Pt. II.):

SERIES I. ARCHICHLAMYDEAE. Perianth in lower stages of development, *i.e.* either (1) absent, (2) simple, in one whorl, petaloid or sepaloid, (3) in two whorls, the inner polyphyllous, (4) in two whorls, the inner gamophyllous (rare; in forms whose nearest relatives are polyphyllous, *e.g.* Correa in Rutaceae), or (5) in one whorl, in consequence of the abortion of the inner whorl.

Cohort 1. *Piperales* (flr. naked or homochlam., ☿ or unisexual; sta. 1—10, cpls. 1—4 free or united; flrs. very small, in spikes; leaves undivided, with stipules or none):

N.O. 48. Saururaceae. 49. Piperaceae. 50. Chloranthaceae. 51. Lacistemaceae.

Cohort 2. *Juglandales* (flr. unisexual, naked or with sepaloid perianth; sta. 2—40; cpls. 2 or 1; ovary 1-loc. with 1 basal orthotropous or rarely parietal amphitropous ovule; drupe; no stipules):

N.O. 52. Juglandaceae. 53. Myricaceae. 54. Leitneriaceae.

Cohort 3. *Salicales* (flr. naked, diœcious, with cup-like disc, sometimes reduced to tooth-like scales; sta. 2—∞, cpls. (2); $\underline{G}$ 1-loc. with ∞ anatropous ovules on parietal placentae; capsule with ∞ seeds; seed small, exalbuminous, with basal tuft of hairs; woody plants with undivided, rarely lobed, alternate, stipulate leaves and spikes of flrs.):

N.O. 55. Salicaceae.

Cohort 4. *Fagales* (flr. cyclic, homochlam., rarely naked, generally unisexual, monœcious; sta. often anteposed to perianth-leaves; cpls. (2—6) each with 1—2 ovules; $\overline{G}$; fruit usually nut-like, 1-seeded; no endosperm; flrs. in simple or compound spikes):

N.O. 56. Betulaceae. 57. Fagaceae.

Order of doubtful position, allied to 56.

N.O. 58. Casuarinaceae (flrs. unisexual; ♂ in spikes, with 2 perianth-leaves and 1 sta.; ♀ in heads, naked, of (2) cpls.; ovules 2, in anterior loc. only, orthotropous, basal; nut enclosed in woody bracteoles; seed exalbuminous).

Cohort 5. *Urticales* (flr. cyclic, homochlam., rarely naked, usually 2-merous, rarely 2 + 3, generally regular; sta. anteposed to perianth-leaves; cpls. 2—1; $\underline{G}$ with 1 ovule; nut; flrs. usually in cymose panicles):

N.O. 59. Ulmaceae. 60. Moraceae. 61. Urticaceae.

Cohort 6. *Proteales* (flr. cyclic, homochlam., usually 2-merous with sta. anteposed to perianth-leaves, hypogynous, ☿ or unisexual, regular or not; perianth petaloid; sta. rarely quite free, usually united to perianth all but the anthers; $\underline{G}$ 1):

N.O. 62. Proteaceae.

Cohort 7. *Santalales* (flr. cyclic, homochlam. with sta. anteposed to perianth-leaves, rarely heterochlam. and haplo- or diplo-stemonous; $\overline{G}$ (2—3) rarely 1, each cpl. with 1 ovule pendulous from apex of loc. or from free-central placenta; sometimes—in order 63—the ovules and placentae are not differentiated, but the embryo-sacs are in the tissue filling the interior of the ovary):

N.O. 63. Loranthaceae. 64. Myzodendraceae. 65. Santalaceae. 66. Grubbiaceae. 67. Olacaceae. 68. Balanophoraceae.

Cohort 8. *Aristolochiales* (flr. cyclic, homochlam., epigynous, regular or zygomorphic; perianth petaloid; ovary usually inferior, 4—6-loc. with axile, or 1-loc. with parietal, placentae and ∞ ovules):

N. O. 69. Aristolochiaceae. 70. Rafflesiaceae. 71. Hydnoraceae.

Cohort 9. *Polygonales* (flr. homo- or hetero-chlam., regular; $\underline{G}$ 1-loc. with 1 erect rarely anatropous ovule; leaves usually with ocreate stipules):

N. O. 72. Polygonaceae.

Cohort 10. *Centrospermae* (flr. acyclic or cyclic, homo- or hetero-chlam.; sta. often as many as and opposite to the perianth-leaves, but also ∞—1; cpls. 1—∞ usually united; $\underline{G}$ rarely multiloc., generally 1-loc. with 1—∞ campylotropous ovules; perisperm; embryo curved; mostly herbs):

N. O. 73. Chenopodiaceae. 74. Amarantaceae. 75. Nyctaginaceae. 76. Cynocrambaceae. 77. Batidaceae. 78. Phytolaccaceae. 79. Aizoaceae. 80. Portulacaceae. 81. Basellaceae. 82. Caryophyllaceae.

Cohort 11. *Ranales* (flr. spiral to cyclic, regular or not, homo- to hetero-chlam., epi- to hypo-gynous, usually with ∞ sta.; cpls. ∞—1, usually free, rarely united):

N. O. 83. Nymphaeaceae. 84. Ceratophyllaceae. 85. Magnoliaceae. 86. Lactoridaceae. 87. Trochodendraceae. 88. Anonaceae. 89. Myristicaceae. 90. Ranunculaceae. 91. Lardizabalaceae. 92. Berberidaceae. 93. Menispermaceae. 94. Calycanthaceae. 95. Monimiaceae. 96. Lauraceae. 97. Hernandiaceae.

Cohort 12. *Rhœadales* (flr. cyclic, except sometimes the sta., hetero-chlam., rarely apetalous or homochlam. [order 103], hypogynous, regular or not; cpls. (∞—2), ovary superior):

N. O. 98. Papaveraceae. 99. Cruciferae. 100. Tovariaceae. 101. Capparidaceae. 102. Resedaceae. 103. Moringaceae.

Cohort 13. *Sarraceniales* (flr. hemicyclic to cyclic, homo- or hetero-chlam., hypogynous, regular; $\underline{G}$ (3—5) with parietal or axile placentae and ∞ ovules; seed small, with endosperm; herbs, usually with alt. entire insect-catching leaves):

N. O. 104. Sarraceniaceae. 105. Nepenthaceae. 106. Droseraceae.

Cohort 14. *Rosales* (flr. cyclic, heterochlam. or apetalous, hypo- to epi-gynous, regular or zygomorphic; cpls. free or united; boundaries of orders badly defined):

N. O. 107. Podostemaceae. 108. Crassulaceae. 109. Cephalotaceae. 110. Saxifragaceae. 111. Cunoniaceae. 112. Myrothamnaceae. 113. Pittosporaceae. 114. Hamamelidaceae. 115. Bruniaceae. 116. Platanaceae. 117. Rosaceae. 118. Connaraceae. 119. Leguminosae.

Cohort 15. *Geraniales* (flr. cyclic, heterochlam. or apetalous, rarely naked, usually 5-merous; andrœceum various; cpls. (5—2), rarely more, in 1 whorl, often separated from one another again when ripe, usually with 2—1 rarely ∞ ovules; ovule with ventral raphe and micropyle facing upwards, or, if > 1 ovule present, some sometimes with dorsal raphe and micropyle facing downwards):

A. Flr. heterochlam., rarely apetalous, usually regular; sta. generally obdiplostemonous, rarely haplostemonous; in the zygomorphic flrs. single sta. often aborted; anthers opening by longitudinal slits; G iso- or oligo-merous; no secretory cells or cavities.

N. O. 120. Geraniaceae. 121. Oxalidaceae. 122. Tropaeolaceae.

123. Linaceae. 124. Humiriaceae. 125. Erythroxylaceae. 126. Zygophyllaceae.

B. As *A*, but secretory cells, cavities or passages present; in order 129 only sometimes in pith and cortex.

N. O. 127. Cneoraceae. 128. Rutaceae. 129. Simarubaceae. 130. Burseraceae. 131. Meliaceae.

C. As *A*, but flrs., at least in gynœceum, obliquely zygomorphic; leaves often opposite.

N. O. 132. Malpighiaceae. 133. Trigoniaceae. 134. Vochysiaceae.

D. Flr. regular or zygomorphic with 2 whorls of sta.; anthers opening by pores; cpls. (2) median.

N. O. 135. Tremandraceae. 136. Polygalaceae.

E. Flr. regular or zygomorphic with 1 whorl of sta.; petals free or united; seed sometimes with caruncle.

N. O. 137. Chailletiaceae (Dichapetalaceae).

F. Flr. regular, unisexual, often much reduced; cpls. usually (3), each with 2—1 ovules.

N. O. 138. Euphorbiaceae.

G. Order of doubtful position.

N. O. 139. Callitrichaceae.

Cohort 16. *Sapindales* (as 15, but ovules in the reverse position, either pendulous with dorsal raphe and micropyle facing upwards, or ascending with ventral raphe and micropyle facing downwards):

A. Flr. with one whorl of perianth.

N. O. 140. Buxaceae.

B. Flr. heterochlam., regular; gynœceum isomerous or pleomerous.

N. O. 141. Empetraceae. 142. Coriariaceae. 143. Cyrillaceae. 144. Limnanthaceae.

C. Flr. heterochlam., sometimes apetalous, always regular; gynœceum rarely isomerous, tending to oligomery.

N. O. 145. Anacardiaceae. 146. Celastraceae. 147. Aquifoliaceae. 148. Stackhousiaceae. 149. Hippocrateaceae. 150. Icacinaceae. 151. Staphyleaceae.

D. Flr. heterochlam., typically diplostemonous, but with abortion of some sta. or cpls., regular or obliquely zygomorphic.

N. O. 152. Aceraceae. 153. Hippocastanaceae. 154. Sapindaceae.

E. Flr. heterochlam., zygomorphic, haplostemonous.

N. O. 155. Sabiaceae. 156. Melianthaceae. 157. Balsaminaceae.

Cohort 17. *Rhamnales* (flr. cyclic, diplochlam., sometimes apetalous, haplostemonous with sta. opp. to petals, regular; cpls. (5—2) each with 1—2 ascending ovules with ventral raphe):

N. O. 158. Rhamnaceae. 159. Vitaceae.

Cohort 18. *Malvales* (flr. cyclic, heterochlam., rarely apetalous, ☿ or rarely unisexual, usually regular; K and C usually 5-merous; K always valvate; sta. ∞ or in 2 whorls with the inner divided; cpls. (2—∞) each with 1—∞ anatropous ovules):

N. O. 160. Elaeocarpaceae. 161. Tiliaceae. 162. Malvaceae. 163. Bombacaceae. 164. Sterculiaceae.

Cohort 19. *Parietales* (flr. cyclic or hemicyclic with often ∞ sta.

and cpls., heterochlam., rarely apetalous, hypo- to epi-gynous; cpls. ± united, often with parietal placentae):

A. Gynœceum free on convex axis.

N. O. 165. Dilleniaceae. 166. Eucryphiaceae. 167. Ochnaceae. 168. Caryocaraceae. 169. Marcgraviaceae. 170. Quiinaceae. 171. Chlaenaceae. 172. Theaceae. 173. Stachyuraceae. 174. Guttiferae. 175. Dipterocarpaceae. 176. Ancistrocladaceae. 177. Elatinaceae. 178. Tamaricaceae. 179. Frankeniaceae. 180. Cistaceae. 181. Bixaceae. 182. Canellaceae. 183. Koeberliniaceae. 184. Violaceae.

B. Gynœceum free on convex or in tubular axis, rarely united laterally.

N. O. 185. Flacourtiaceae. 186. Turneraceae. 187. Malesherbiaceae. 188. Passifloraceae. 189. Caricaceae.

C. Gynœceum sunk in axis and united with it.

N. O. 190. Loasaceae. 191. Begoniaceae. 192. Datiscaceae.

Cohort 20. *Opuntiales* (flr. hemicyclic, heterochlam., with ∞ spiral K, C, A, on tubular axis, and 4—∞ cpls. forming an inferior ovary):

N. O. 193. Cactaceae.

Cohort 21. *Thymelaeales* (flr. cyclic, haplo- or hetero-chlam., or apetalous, haplo- or diplo-stemonous, regular; axis tubular, at least in ☿ and ♀ flrs.; cpls. (2—4) forming free gynœceum; mostly woody plants, rarely herbs with undivided leaves):

N. O. 194. Geissolomaceae. 195. Penaeaceae. 196. Oliniaceae. 197. Thymelaeaceae. 198. Elaeagnaceae.

Cohort 22. *Myrtiflorae* (flr. cyclic, heterochlam., rarely apetalous, haplo- or diplo-stemonous; axis tubular; G (2—∞), rarely free, usually united to axis; herbs and woody plants with alternate or more often opposite or whorled leaves):

N. O. 199. Lythraceae. 200. Blattiaceae. 201. Punicaceae. 202. Lecythidaceae. 203. Rhizophoraceae. 204. Myrtaceae. 205. Combretaceae. 206. Melastomaceae. 207. Onagraceae. 208. Hydrocaryaceae. 209. Haloragidaceae.

Cohort 23. *Umbelliflorae* (flr. cyclic, heterochlam., usually haplostemonous, epigynous, 5—4-, rarely ∞-merous, usually ☿, regular; cpls. (5—1) or (∞), each with 1 or rarely 2 pendulous anatropous ovule; seed with rich endosperm; flrs. usually in umbels):

N. O. 210. Araliaceae. 211. Umbelliferae. 212. Cornaceae.

SERIES II. SYMPETALAE. Perianth in higher stage of development, always originally in 2 whorls, the inner gamophyllous (in a few cases polyphyllous or absent, though normal in closely related forms).

Cohort 1. *Ericales* (flr. 5—4-merous, obdiplostemonous or the sta. before the petals absent, ☿, usually regular; petals free or united; sta. hypo- or epi-gynous, rarely united to corolla at base; cpls. (2—∞), when isomerous usually opposite to petals; ovary superior to inferior):

N. O. 213. Clethraceae. 214. Pyrolaceae. 215. Lennoaceae. 216. Ericaceae. 217. Epacridaceae. 218. Diapensiaceae.

Cohort 2. *Primulales* (flr. 5- or rarely 4—∞-merous, typically diplostemonous, but usually haplostemonous with sta. opposite to petals and epipetalous, ☿ or unisexual, usually regular; petals rarely free; ovary superior to inferior, 1-loc. with ∞—1 ovules on basal or free-central placenta):

N. O. 219. Myrsinaceae. 220. Primulaceae. 221. Plumbaginaceae.

Cohort 3. *Ebenales* (flr. diplo- or triplo-stemonous, or haplostemonous by abortion, rarely with ∞ sta.; petals united; ovary multi-loc. with axile placentae, and 1 or few ovules in each loc.):

N. O. 222. Sapotaceae. 223. Ebenaceae. 224. Symplocaceae. 225. Styracaceae.

Cohort 4. *Contortae* (flr. usually 5-, rarely 2- to 6-merous, usually sympetalous; sta. usually as many as petals, sometimes fewer, rarely hypogynous, usually united at base to corolla; cpls. (2); corolla usually convolute, sometimes valvate; leaves usually opposite, undivided and exstipulate):

N. O. 226. Oleaceae. 227. Salvadoraceae. 228. Loganiaceae. 229. Gentianaceae. 230. Apocynaceae. 231. Asclepiadaceae.

Cohort 5. *Tubiflorae* (flr. typically with 4 isomerous whorls, or more often with reduction in gynœceum, or if zygomorphic also in andrœceum; sta. epipetalous):

A. Flr. usually regular; cpl. with few or 2 ovules; leaves usually alternate.

N. O. 232. Convolvulaceae. 233. Polemoniaceae. 234. Hydrophyllaceae. 235. Boraginaceae.

B. Flr. usually zygomorphic; cpl. with 2 or rarely 1 ovules; leaves usually opposite or whorled.

N. O. 236. Verbenaceae. 237. Labiatae. 238. Phrymaceae.

C. Flr. regular or more often zygomorphic, typically 5-merous; sta. 5, 4, or 2; cpls. rarely (5), usually (2), with mostly ∞, rarely 2—1 ovules; fruit usually a capsule, sometimes a berry or drupe; capsule loculicidal only just to the base.

N. O. 239. Nolanaceae. 240. Solanaceae. 241. Scrophulariaceae. 242. Lentibulariaceae. 243. Orobanchaceae. 244. Gesneraceae. 245. Columelliaceae. 246. Bignoniaceae. 247. Pedaliaceae. 248. Martyniaceae. 249. Globulariaceae.

D. Like *C*, but capsule loculicidal to very base.

N. O. 250. Acanthaceae.

E. Flr. 5-merous, regular or zygomorphic; cpls. (2), each with 2—4—8 ovules, or (2—∞), each with 1 pendulous ovule with micropyle facing upwards; drupe, with chambered endocarp or 2—∞ stones.

N. O. 251. Myoporaceae.

Cohort 6. *Plantaginales* (flr. 4-merous, isomerous except in cpls., ☿ or unisexual, regular; leaves alternate):

N. O. 252. Plantaginaceae.

Cohort 7. *Rubiales* (flr. typically 5—4-merous with isomerous sta. and cpls., or with latter oligomerous, regular or zygomorphic; $\overline{G}$ multi-loc., with ∞—1 anatropous ovules in each loc.):

N. O. 253. Rubiaceae. 254. Caprifoliaceae. 255. Adoxaceae (?).

Cohort 8. *Aggregatae* (flr. typically 5-merous with fewer sta. and cpls., zygomorphic or asymmetric; $\overline{G}$ with only 1 fertile loc. and 1 pendulous ovule):

N. O. 256. Valerianaceae. 257. Dipsaceae.

Cohort 9. *Campanulatae* (flr. typically 5-merous with usually fewer cpls.; anthers close together, often united; $\overline{G}$ multiloc. with ∞—1 ovules in the loculi, or 1-loc. with 1 ovule):

N. O. 258. Cucurbitaceae. 259. Campanulaceae. 260. Goodeniaceae. 261. Candolleaceae. 262. Calyceraceae. 263. Compositae.

SYSTEM OF BENTHAM AND HOOKER, 1862—93.

PHANEROGAMAE.

I. Dicotyledones (as above).

I. Polypetalae (flr. usually with two whorls of perianth, the inner polyphyllous: exceptions as in Engler's system):

SERIES I. THALAMIFLORAE. Sepals usually distinct and separate, free from ovary; petals 1-, 2- to ∞-seriate, hypogynous; sta. hypogynous, rarely inserted on a short or long torus or on a disc; ovary superior.

Cohort 1. *Ranales* (sta. rarely definite; cpls. free or immersed in torus, very rarely united; micropyle usually inferior; embryo minute in fleshy albumen):

N.O. 1. Ranunculaceae. 2. Dilleniaceae. 3. Calycanthaceae. 4. Magnoliaceae. 5. Anonaceae. 6. Menispermaceae. 7. Berberideae. 8. Nymphaeaceae.

Cohort 2. *Parietales* (sta. definite or ∞; cpls. united into a 1-loc. ovary with parietal placentae, rarely spuriously 2- or more-loc. by prolongation of placentae):

N.O. 9. Sarraceniaceae. 10. Papaveraceae. 11. Cruciferae. 12. Capparideae. 13. Resedaceae. 14. Cistineae. 15. Violarieae. 16. Canellaceae. 17. Bixineae.

Cohort 3. *Polygalinae* (K and C 5, rarely 4 or 3; sta. as many or twice as many as petals; ovary 2-, rarely 1- or more-loc.; endosperm fleshy, rarely absent; herbs or shrubs with exstip. leaves):

N.O. 18. Pittosporeae. 19. Tremandreae. 20. Polygaleae. 21. Vochysiaceae.

Cohort 4. *Caryophyllinae* (flr. regular; K 2—5, rarely 6; petals usually as many; sta. as many or twice as many, rarely more or fewer; ovary 1-loc. or imperfectly 2—5-loc.; placenta free-central, rarely parietal; embryo usually curved in floury albumen):

N.O. 22. Frankeniaceae. 23. Caryophylleae. 24. Portulaceae. 25. Tamariscineae.

Cohort 5. *Guttiferales* (flr. regular; K and C usually 4—5, imbricate; sta. usually ∞; ovary 3—∞-loc., rarely 2-loc. or of 1 cpl.; placentae on inner angles of loculi):

N. O. 26. Elatineae. 27. Hypericineae. 28. Guttiferae. 29. Ternstrœmiaceae. 30. Dipterocarpeae. 31. Chlaenaceae.

Cohort 6. *Malvales* (flr. rarely irregular; K 5, rarely 2—4, free or united, valvate or imbricate; petals as many or 0; sta. usually ∞, monadelphous; ovary 3—∞-loc., rarely of 1 cpl.; ovules in inner angles of loculi):

N.O. 32. Malvaceae. 33. Sterculiaceae. 34. Tiliaceae.

SERIES II. DISCIFLORAE. Sepals distinct or united, free or adnate to ovary; disc usually conspicuous as a ring or cushion, or spread over the base of the calyx-tube, or confluent with the base of the ovary, or broken up into glands; sta. usually definite, inserted upon or at the outer or inner base of the disc; ovary superior.

Cohort 7. *Geraniales* (flrs. often irregular; disc usually annular, adnate to the sta. or reduced to glands, rarely 0; ovary of several cpls., syncarpous or sub-apocarpous; ovules 1—2, rarely ∞, ascending or pendulous; raphe usually ventral):

N.O. 35. Lineae. 36. Humiriaceae. 37. Malpighiaceae. 38. Zygophylleae. 39. Geraniaceae. 40. Rutaceae. 41. Simarubeae. 42. Ochnaceae. 43. Burseraceae. 44. Meliaceae. 45. Chailletiaceae.

Cohort 8. *Olacales* (flr. regular, ☿ or unisexual; calyx small; disc free, cupular or annular, rarely glandular or 0; ovary entire, 1—∞-loc.; ovules 1—3 in each loc., pendulous; raphe dorsal, integuments confluent with the nucellus; endosperm usually copious, fleshy; embryo small; shrubs or trees; leaves alt., simple, exstip.):

N.O. 46. Olacineae. 47. Ilicineae. 48. Cyrilleae.

Cohort 9. *Celastrales* (flr. regular, ☿; corolla hypo- or peri-gynous; disc tumid, adnate to base of calyx-tube or lining it; sta. = petals or fewer, rarely twice as many, perigynous or inserted outside the disc or on its edge; ovary usually entire; ovules 1—2 in each loc., erect with ventral raphe; leaves simple, except in order 52):

N.O. 49. Celastrineae. 50. Stackhousieae. 51. Rhamneae. 52. Ampelideae.

Cohort 10. *Sapindales* (flr. often irregular and unisexual; disc tumid, adnate to base of calyx or lining its tube; sta. perigynous or inserted upon the disc or between it and the ovary, usually definite; ovary entire, lobed or apocarpous; ovules 1—2 in each loc. usually ascending with a ventral raphe, or reversed, or pendulous from a basal funicle, rarely ∞ horizontal; seed usually exalbuminous; embryo often curved or crumpled; shrubs or trees, leaves usually compound):

N.O. 53. Sapindaceae. 54. Sabiaceae. 55. Anacardiaceae.

Anomalous orders or rather genera:

N.O. 56. Coriarieae. 57. Moringeae.

SERIES III. CALYCIFLORAE. Sepals united, rarely free, often adnate to ovary; petals 1-seriate, peri- or epi-gynous; disc adnate to base of calyx, rarely tumid or raised into a torus or gynophore; sta. perigynous, usually inserted on or beneath the outer margin of the disc: ovary often inferior.

Cohort 11. *Rosales* (flr. usually ☿, regular or irregular; cpls. 1 or more, usually quite free in bud, sometimes variously united afterwards with the calyx-tube or enclosed in the swollen top of the peduncle; styles usually distinct):

N.O. 58. Connaraceae. 59. Leguminosae. 60. Rosaceae. 61.

Saxifrageae. 62. Crassulaceae. 63. Droseraceae. 64. Hamamelideae. 65. Bruniaceae. 66. Halorageae.

Cohort 12. *Myrtales* (flr. regular or sub-regular, usually ☿; ovary syncarpous, usually inferior; style undivided, or very rarely styles free; placentae axile or apical, rarely basal; leaves simple, usually quite entire, rarely 3-foliolate in order 68):

N.O. 67. Rhizophoraceae. 68. Combretaceae. 69. Myrtaceae. 70. Melastomaceae. 71. Lythrarieae. 72. Onagrarieae.

Cohort 13. *Passiflorales* (flr. usually regular, ☿ or unisexual; ovary usually inferior, syncarpous, 1-loc. with parietal placentae, sometimes 3- or more-loc. by the produced placentae; styles free or connate):

N.O. 73. Samydaceae. 74. Loaseae. 75. Turneraceae. 76. Passifloreae. 77. Cucurbitaceae. 78. Begoniaceae. 79. Datisceae.

Cohort 14. *Ficoidales* (flr. regular or sub-regular; ovary syncarpous, inferior to superior, 1-loc. with parietal, or 2—∞-loc. with axile or basal placentae; embryo curved, with endosperm, or cyclical, or oblique with no endosperm):

N.O. 80. Cacteae. 81. Ficoideae.

Cohort 15. *Umbellales* (flr. regular, usually ☿; sta. usually definite; ovary inferior, 1—2—∞-loc.; ovules solitary, pendulous in each loc. from its apex; styles free or united at base; seeds with endosperm; embryo usually minute):

N.O. 82. Umbelliferae. 83. Araliaceae. 84. Cornaceae.

II. Gamopetalae (flr. usually with two whorls of perianth, the inner gamophyllous; exceptions as in Engler's system):

SERIES I. INFERAE. Ovary inferior; sta. usually as many as corolla-lobes.

Cohort 1. *Rubiales* (flr. regular or irregular; sta. epipetalous; ovary 2—∞-loc., with 1—∞ ovules in each loc.):

N.O. 85. Caprifoliaceae. 86. Rubiaceae.

Cohort 2. *Asterales* (flr. regular or irregular; sta. epipetalous; ovary 1-loc., 1-ovuled, sometimes > 1-loc. but with only 1 ovule):

N.O. 87. Valerianeae. 88. Dipsaceae. 89. Calycereae. 90. Compositae.

Cohort 3. *Campanales* (flr. usually irregular; sta. usually epigynous; ovary 2—6-loc., with usually ∞ ovules in each loc.):

N.O. 91. Stylidieae. 92. Goodenovieae. 93. Campanulaceae.

SERIES II. HETEROMERAE. Ovary usually superior; sta. epipetalous or free from corolla, opposite or alternate to its segments, or twice as many, or ∞; cpls. > 2.

Cohort 4. *Ericales* (flr. usually regular and hypogynous; sta. as many or twice as many as petals; ovary 1—∞-loc. with 1—∞ ovules in each loc.; seeds minute):

N.O. 94. Ericaceae. 95. Vaccinieae. 96. Monotropeae. 97. Epacrideae. 98. Diapensiaceae. 99. Lennoaceae.

Cohort 5. *Primulales* (corolla usually regular and hypogynous, sta. usually = and opposite to corolla-lobes; ovary 1-loc. with free-central or basal placenta and 1—∞ ovules):

N.O. 100. Plumbagineae. 101. Primulaceae. 102. Myrsineae.

Cohort 6. *Ebenales* (corolla usually hypogynous; sta. usually more than corolla-lobes, or if as many, then opposite to them, except in 103, often ∞ ; ovary 2—∞-loc. ; ovules usually few; trees or shrubs) :

N.O. 103. Sapotaceae. 104. Ebenaceae. 105. Styraceae.

SERIES III. BICARPELLATAE. Ovary usually superior; sta. as many as or fewer than corolla-lobes, alternate to them; cpls. 2, rarely 1 or 3.

Cohort 7. *Gentianales* (corolla regular, hypogynous; sta. epipetalous; leaves generally opposite):

N.O. 106. Oleaceae. 107. Salvadoraceae. 108. Apocynaceae. 109. Asclepiadaceae. 110. Loganiaceae. 111. Gentianaceae.

Cohort 8. *Polemoniales* (corolla regular, hypogynous; sta. = corolla-lobes, epipetalous; ovary 1—5-loc.; leaves generally alternate):

N.O. 112. Polemoniaceae. 113. Hydrophyllaceae. 114. Boragineae. 115. Convolvulaceae. 116. Solanaceae.

Cohort 9. *Personales* (flr. usually very irregular; corolla hypogynous, often 2-lipped; sta. generally fewer than corolla-lobes, usually 4, didynamous, or 2; ovary 1—2- or rarely 4-loc.; ovules usually ∞):

N.O. 117. Scrophularineae. 118. Orobanchaceae. 119. Lentibularieae. 120. Columelliaceae. 121. Gesneraceae. 122. Bignoniaceae. 123. Pedalineae. 124. Acanthaceae.

Cohort 10. *Lamiales* (corolla usually 2-lipped, hypogynous, rarely regular; sta. as in preceding; ovary 2—4-loc. ; ovules solitary in loc., or rarely > 1 in orders 125 and 127; fruit a drupe or nutlets):

N.O. 125. Myoporineae. 126. Selagineae. 127. Verbenaceae. 128. Labiatae.

Anomalous Order:

N.O. 129. Plantagineae.

III. Monochlamydeae or Incompletae (flr. usually with one whorl of perianth, commonly sepaloid, or none):

SERIES I. CURVEMBRYAE. Terrestrial plants with usually ☿ flrs.; sta. generally = perianth-segments; ovule usually solitary; embryo curved in floury endosperm.

N.O. 130. Nyctagineae. 131. Illecebraceae. 132. Amarantaceae. 133. Chenopodiaceae. 134. Phytolaccaceae. 135. Batideae. 136. Polygonaceae.

SERIES II. MULTIOVULATAE AQUATICAE. Aquatic plants with syncarpous ovary and ∞ ovules.

N.O. 137. Podostemaceae.

SERIES III. MULTIOVULATAE TERRESTRES. Terrestrial plants with syncarpous ovary and ∞ ovules.

N.O. 138. Nepenthaceae. 139. Cytinaceae. 140. Aristolochieae.

SERIES IV. MICREMBRYAE. Ovary syn- or apo-carpous; ovules usually solitary; embryo very small, surrounded by endosperm.

N.O. 141. Piperaceae. 142. Chloranthaceae. 143. Myristiceae. 144. Monimiaceae.

SERIES V. DAPHNALES. Ovary usually of 1 cpl.; ovules solitary or few; perianth perfect, sepaloid, in 1 or 2 whorls; sta. perigynous.

N.O. 145. Laurineae. 146. Proteaceae. 147. Thymelaeaceae. 148. Penaeaceae. 149. Elaeagnaceae.

SERIES VI. ACHLAMYDOSPOREAE. Ovary 1-loc., 1—3-ovuled; ovules not apparent till after fertilisation; seed with endosperm, but no testa, adnate to receptacle or pericarp.

N. O. 150. Loranthaceae. 151. Santalaceae. 152. Balanophoreae.

SERIES VII. UNISEXUALES. Flrs. unisexual; ovary syncarpous or of 1 cpl.; ovules solitary or 2 per cpl.; endosperm or none; perianth sepaloid or much reduced or absent.

N. O. 153. Euphorbiaceae. 154. Balanopseae. 155. Urticaceae. 156. Platanaceae. 157. Leitnerieae. 158. Juglandeae. 159. Myricaceae. 160. Casuarineae. 161. Cupuliferae.

SERIES VIII. ANOMALOUS ORDERS. Unisexual orders of doubtful or unknown affinities.

N. O. 162. Salicaceae. 163. Lacistemaceae. 164. Empetraceae. 165. Ceratophylleae.

II. Gymnospermae (as in Engler).

N. O. 166. Gnetaceae. 167. Coniferae. 168. Cycadeae.

III. Monocotyledones (as in Engler).

SERIES I. MICROSPERMAE. Inner perianth petaloid; ovary inferior with 3 parietal or rarely axile placentae; seeds minute, exalbuminous.

N. O. 169. Hydrocharideae. 170. Burmanniaceae. 171. Orchideae.

SERIES II. EPIGYNAE. Perianth partly petaloid; ovary usually inferior; endosperm abundant.

N. O. 172. Scitamineae. 173. Bromeliaceae. 174. Haemodoraceae. 175. Irideae. 176. Amaryllideae. 177. Taccaceae. 178. Dioscoreaceae.

SERIES III. CORONARIEAE. Inner perianth petaloid; ovary usually free, superior; endosperm abundant.

N.O. 179. Roxburghiaceae. 180. Liliaceae. 181. Pontederiaceae. 182. Philydraceae. 183. Xyrideae. 184. Mayacaceae. 185. Commelinaceae. 186. Rapateaceae.

SERIES IV. CALYCINAE. Perianth sepaloid, herbaceous or membranous; ovary &c. as in III.

N. O. 187. Flagellarieae. 188. Juncaceae. 189. Palmae.

SERIES V. NUDIFLORAE. Perianth none, or represented by hairs or scales; cpl. 1 or several syncarpous; ovary superior; ovules 1—∞; endosperm usually present.

N.O. 190. Pandaneae. 191. Cyclanthaceae. 192. Typhaceae. 193. Aroideae. 194. Lemnaceae.

SERIES VI. APOCARPAE. Perianth in 1 or 2 whorls, or none; ovary superior, apocarpous; no endosperm.

N. O. 195. Triurideae. 196. Alismaceae. 197. Naiadaceae.

SERIES VII. GLUMACEAE. Flrs. solitary, sessile in the axils of bracts and arranged in heads or spikelets with bracts; perianth of scales, or none; ovary usually 1-loc., 1-ovuled; endosperm.

N. O. 198. Eriocauleae. 199. Centrolepideae. 200. Restiaceae. 201. Cyperaceae. 202. Gramineae.

SYSTEM OF EICHLER (AND WARMING).

Gymnospermae (as in Engler).

Angiospermae.

I. Monocotyledones.

Cohort 1. *Helobieae*=coh. 2 of Engler.
2. *Glumiflorae*=coh. 3+order 33.
3. *Spadiciflorae*=coh. 1, 4, 5 and 6.
4. *Enantioblastae*=orders 23—27 and 30.
5. *Liliiflorae*=coh. 8 and orders 22, 28, 29, 31, 32.
6. *Scitamineae*=coh. 9.
7. *Gynandrae*=coh. 10.

II. Dicotyledones.

SERIES I. CHORIPETALAE (=Archichlamydeae).

Cohort 1. *Saliciflorae*=coh. 3 of Engler.
2. *Querciflorae*=coh. 4.
3. *Juglandiflorae*=coh. 2.
4. *Urticiflorae*=coh. 5+order 58.
5. *Polygoniflorae*=coh. 1 and 9.
6. *Curvembryae*=coh. 10.
7. *Cactiflorae*=coh. 20.
8. *Polycarpicae*=coh. 11.
9. *Rhœadinae*=coh. 12 (part).
10. *Cistiflorae*=coh. 13 and parts of 12 and 19.
11. *Gruinales*=parts of coh. 15 and 16.
12. *Columniferae*=coh. 18.
13. *Tricoccae*=parts of coh. 15 and 16.
14. *Terebinthinae*=parts of coh. 15 and 16.
15. *Aesculinae*=parts of coh. 15 and 16.
16. *Frangulinae*=coh. 17 and part of 16.
17. *Thymelaeinae*=coh. 21 and 6.
18. *Saxifraginae*=coh. 14 (except orders 117, 119).
19. *Rosiflorae*=order 117.
20. *Leguminosae*=order 119.
21. *Passiflorinae*=part of coh. 19 and order 258.
22. *Myrtiflorae*=coh. 22.
23. *Umbelliflorae*=coh. 23.
24. *Hysterophyta*=coh. 7 and 8.

SERIES II. SYMPETALAE.

Cohort 1. *Bicornes*=coh. 1 of Engler.
2. *Diospyrinae*=coh. 3.
3. *Primulinae*=coh. 2.
4. *Tubiflorae*=orders 232—234.
5. *Personatae*=part of coh. 5 and coh. 6.
6. *Nuculiferae*=part of coh. 5.
7. *Contortae*=coh. 4.

Cohort 8. *Rubiales*=coh. 7 and order 256.
9. *Campanulinae*=part of coh. 9.
10. *Aggregatae*=orders 257, 262 and 263.

It will be noticed that the two German systems agree in making only two chief groups of Dicotyledons; the English system, on the other hand, makes a third group, the Incompletae, which is decidedly artificial, separating for instance the Chenopodiaceae, &c. far from the Caryophyllaceae to which they are closely allied. In general, the composition of the smaller groups of orders is much the same in all systems; the differences lie chiefly in the composition and arrangement of the larger groups, as is easily understood from what we have said above. The elementary student should not concern himself with any system of classification until he is well acquainted with a number of orders (see p. 4): he should then carefully study the systems above given and endeavour to discover why their authors have placed such and such orders in the places assigned to them in the various systems. In this way he will gain an insight into the principles of classification. The relationships of many of the orders are discussed in Pt. II. When the student is familiar with 40 or 50 orders, occupying different places in the system he adopts, he will be able to classify approximately any new order that may be presented to him, by determining its affinities to those he already knows. It must be clearly understood that the attempt to use the system to determine the order to which a plant belongs will only lead to difficulties unless the student is already familiar with typical orders from many parts of the system. In actual systematic practice, little if any use is made of the larger groupings, and the position of a plant in the system is recognised by its affinities to others whose positions are known.

Identification of Natural Orders at sight. After a time, the student will find himself becoming able in many cases to recognise at a glance the natural order to which a plant belongs, and after a few years' practice, he should be able in this way to classify most of the plants met with in the field or in a botanic garden. Sometimes the order can be recognised from its general habit, or from belonging to a limited group, *e.g.* water-plants or parasites, in other cases it can be identified with certainty only when in flower.

Thus the Ferns, Equisetaceae, Selaginellas, Cycads, Conifers, Palms, most Araceae, Pandanaceae, Bromeliaceae, Musaceae, Sarraceniaceae, Droseraceae, Cactaceae, Lentibulariaceae, &c. are recognisable by their general habit; Cannaceae, Marantaceae, Zingiberaceae, most Polygonaceae, many Rutaceae and allied orders, Melastomaceae, &c. by their habit taken together with some peculiarity of the vegetative organs; the inflorescence enables one to recognise Typhaceae, Piperaceae, Salicaceae, Betulaceae, Fagaceae, Umbelliferae and their allies, Boraginaceae and allied orders, Dipsaceae and Compositae; obvious floral characters point out such families as Gramineae, Cyperaceae, Liliaceae, Orchidaceae, Proteaceae, Ranunculaceae, Cruciferae, Leguminosae, most Rosaceae, Polygalaceae, Malvaceae and their allies, Melastomaceae, Umbelliferae, Ericaceae, Primulaceae, Asclepiadaceae, Boraginaceae, Labiatae, Rubiaceae, Compositae, &c. When a plant belongs to one of the biological groups described in Ch. III., its identification is often rendered easy by the small number of plants with which comparison has to be made.

CHAPTER III.

FORMS OF VEGETATION, GEOGRAPHICAL DISTRIBUTION OF PLANTS, &c.

In dealing with general morphology we have seen that the reproductive organs are subject to modification chiefly in accordance with the necessities of the pollination processes. The vegetative organs on the other hand are intimately related in their structural and other features to the conditions of climate and habitat under which they exist, and in comparing plants from different regions we often find great dissimilarity of the vegetative together with great similarity of the reproductive systems. It is with this side of the subject that we have now to deal, considering the vegetation of different regions and habitats both from the morphological and physiological points of view; we shall thus endeavour to gain an insight at the same time into the subjects of morphology, natural history, and geographical distribution of plants. Thus the various forms of stems usually described together in morphological works as modified stems will be found treated here, but their structure is dealt with in connection with their functions, so as to emphasise the important fact that modification of the former accompanies modification of the latter.

Geographical Distribution of Plants, or **Geographical Botany**[1], deals with problems connected with

[1] A. de Candolle, *Géographie botanique raisonnée*, 1855; J. D. Hooker, *Flora of Australia* (Introductory Essay to Flora of Tasmania, in Botany of Antarctic Exp., 1859), *Introductory Essay to Flora of New Zealand*, 1st Ed., 1853; Grisebach, *Die Vegetation der Erde*, 1872; Drude, *Handbuch der Pflanzengeographie*, 1890 (or French translation by Poirault), *Atlas der Pflanzenverbreitung*; Warming, *Oekologische Pflanzengeographie* (German by Knoblauch), Schimper, *Pflanzengeographie auf physiologischer Grundlage*, 1898; Darwin, *Origin of Species*, &c.; Köppen, *Versuch einer Klassifikation d. Klimate*, Geog. Zeitschr. Leipzig, 1901.

the distribution of plants over the surface of the globe. The first groundwork necessarily is the preparation of *floras*, *i.e.* accurate lists of the various species of plants growing in the different regions to be dealt with. At the same time the exact boundaries of the distribution of the various species must be determined, and the same for the genera and the natural orders. Given these preliminary facts we may then go on to deal with such questions as the following. Why is the flora of a given country composed of certain species and no others? How did these species get into the country, from what place, and at what time? Did they originate in the country where they are now found, or somewhere else, and if so where? Into what associations are the plants of a given flora grouped, and what is the cause of their grouping? What is the general physiognomy and ecology of these groups? Why is the flora of Europe different from that of similar areas in North America or elsewhere? Why is any given species, genus, or family confined to a certain area and not found elsewhere, though the conditions of life be favourable? Why is the area occupied by a species (or genus or family) usually continuous, but frequently disjointed or broken up into separate areas? Why are there so many species or genera which occur solely in one spot, most often one island or one mountain chain (such a species or genus is termed *endemic*), and why are such areas characterised by the possession of endemic forms? Why do certain species occur only on the various mountain-ranges (*e.g.* on the Alps, Pyrenees, and Carpathians) and not in the intervening lowlands? Why are some species common to Europe and New Zealand? Such questions and many others require solution; it is evident that to deal properly with them we require an extended knowledge of the general ecology of the plants, as well as of their phylogeny. At the same time, the study of geographical botany throws light on these subjects in turn.

Distribution of Species, Genera, &c., and limitation of Area. A species probably arises in a certain limited area of the earth's surface, and spreads from this point by aid of the seed-dispersal methods and by vegetative reproduction. We can see this process of spreading actually going on in the case of such plants as Lespedeza, Salsola, Mimosa, Gomphocarpus, Galinsoga, Elodea, which have been introduced by man into countries where they did not previously exist. Their rapid spread shows that in long periods any species, however poor its dispersal mechanism, might cover a large part of the earth, if no other cause prevented this result. How far the species spreads will evidently depend upon its general ecology; it may be admirably adapted to the circumstances of its original environment, but when its dispersal mechanisms carry it into different climatic circumstances, or different associations of competing plants, it may be unable to hold its own. If very adaptable or very well equipped it may continue to spread, diverging into new species or varieties as it goes, till the genus thus formed may cover an immense area. The causes which limit the area occupied by a species are many. They may be divided into the *geographical* agents, those which vary with locality, *e.g.* light, heat and moisture, the *topographical* agents, *e.g.* mountains, rivers, seas, the constitution of the soil, &c., the *biological* agents, *e.g.* the distribution of insects and other animals, the mutual competition of organisms, the dependence of one organism upon another, and so on. Last but not least, account has to be taken of the conclusions of geology with regard to alterations in the configuration and climate of the earth's surface, for most of our existing species are descended from forms that existed under different environments.

Light varies much in different latitudes. In the tropics the day is always about 12 hours long, the light nearly vertical at midday, while in the arctic regions there is long-continued darkness in winter, and almost continuous light in summer, falling from every side in turn as the sun describes its daily course. The amount of assimilation depends largely upon the amount and intensity of the light. Plants of high latitudes go through their vegetative period more rapidly than those of low. Many plants require brilliant light for full success, others prefer weak light or shade; this difference comes out in their structure, *e.g.* in the *sun-plants* the stems are often short, light retarding growth, the leaves often turned edgewise (p. 49), the palisade-tissue more developed.

Heat also depends largely on the latitude, but shows more local variation than light. Plant functions depend on temperature (p. 35), and thus the range of temperature in a locality becomes an important factor in determining the species of plants inhabiting it, for some can stand high, some low, temperatures best; others prefer uniformity of temperature rather than great range. Plants which contain much water are less able to stand extreme cold than those which contain little. High temperatures increase transpiration, and plants with insufficient protection against this will only be able to live in hot countries where there is plenty of moisture.

Atmospheric Moisture, Rain, Snow, &c. Of the three geographical agents in determining distribution, this is perhaps the chief, water being of such very great importance in plant-life. The effects of variation in the degree of saturation of the air are chiefly visible in the transpiration (p. 33); plants transpire the more the drier the air is. A plant must also regulate its transpiration according to the amount of water available for absorption by the roots. Plants show extreme structural variety corresponding to their rates of transpiration; those living in very dry climates often differ extremely from those in wet (see below, Xerophytes, Shore-plants, Epiphytes, Water-plants, &c.).

If the temperature of the air sink sufficiently, precipitation of some of the vapour occurs, as clouds, mist, fog, rain, hail, snow, dew, &c. Upon the form and amount of this precipitation the flora of a region largely depends. Plants living where there is long-continued mist, *e.g.* many alpines, must be able to do without direct sunlight, and to stand a saturated atmosphere. Wiesner divides plants into *ombrophiles*, which can undergo without injury long-continued rain, and *ombrophobes*, whose leaves soon decay or fall off under such circumstances; the plants of the wet tropics belong mostly to the former, those of deserts to the latter, group. A leaf, for the proper performance of its functions, must keep its surface dry. In wet regions adaptations for this purpose occur; the most frequent is the *drip-tip* (Träufelspitze) or acuminate leaf-apex, a long fine point from which water rapidly drips off. It only occurs on leaves whose surfaces are easily wetted; many leaves of wet climates have polished surfaces from which water at once runs off, *e.g.*

Ficus elastica. The most remarkable drip-tip is that of *Ficus religiosa*; others occur in Acer, Artocarpus, Begonia, Boehmeria, Theobroma, &c. Many tropical fruits exhibit similar apices, *e.g.* Kigelia, Mucuna. These leaves are generally pendulous with the point downwards, and have usually entire margins; they form the class of leaves termed by Jungner *rain-leaves.* He proposes a second class of *dew-leaves*, occurring chiefly at the boundaries of deserts and steppes; they slope upwards so that water flows from them towards the stem, are obovate, and sessile or shortly stalked. A third class is the *snow-leaves* (see Alpine plants, below)[1].

Wind tends to increase transpiration and in very windy places plants occur with a certain amount of extra protection against evaporation. Wind also dries the soil and thus tends to check absorption of water by the roots.

All these agents are more or less markedly *periodic* in their action, and in nearly all plants there is a *periodicity* in the life history corresponding to that of the geographical agents. In temperate climates this is chiefly determined by the temperature, vegetative activity ceasing in autumn to be resumed in spring. In sub-tropical climates (*e.g.* that of the Mediterranean coasts, &c.) the interruption of vegetative activity occurs in summer when the heat is great and the drought extreme. Even in tropical climates proper, with comparatively uniform weather, most plants show a periodicity in the formation of new leaves, flowers, &c. The study of the periodic phenomena of vegetation—dates of flowering, fruiting, &c.—is termed *phaenology.* The periodicity is not merely annual but also daily, as instanced by the phenomena of growth, &c. Removal of a plant to a region of different climate does not at once or necessarily destroy the periodicity, which is hereditary and ingrained; this is illustrated by the way in which plants from the southern hemisphere continue to flower in our conservatories during the winter months of our year, corresponding to the southern summer. At the same time the periodicity is not as a rule unalterable, and *acclimatisation* of plants, or alteration of their periodi-

[1] Stahl, *Regenfall und Blattgestalt*, Ann. Buitenz. 1893; Jungner, *Klima und Blatt in der Regio Alpina*, Flora 1894; Wiesner in Sitzb. k. k. Akad. Wien, 1893, 1894.

city to suit other climates, is largely practised, and with success in many cases, especially if the change be not too marked.

Physical Barriers. Of the topographical agents in determining the distribution of species, the natural physical barriers are very important, *e.g.* seas, oceans, deserts, mountain-chains, &c. At the same time many plants are able to pass over wide expanses of water or over ranges of mountains (p. 109); these however are but few in proportion to the whole flora, and generally the floras on opposite sides of a great natural barrier are almost completely different. Ranges of mountains also act as pathways of migration by reason of the new soil frequently exposed in landslips or otherwise; thus species with good dispersal mechanisms may travel along the whole range and get into new countries.

The actual elevation of the mountains has also an important effect, for the temperature decreases with increase of elevation, while the humidity often increases, and the air is less dense. The steepness of slopes, and their exposure, are also important factors, regulating drainage and exposure to the sun (*insolation*). In Europe a southern slope is warmer than a northern, in the tropics an eastern than a western, because the sky is usually clearer in the morning.

Soil. The nature of the soil has a great effect upon the composition of the flora growing upon it (*edaphic* influence). Probably the chemical composition of the soil produces more effect than the physical. Thus we have a group of plants which grow by preference on soils with much silica (sand), another on chalky soils, and a third on salt soil (halophytes, see below). The amount of water the soil is able to retain is a factor of much importance; so also is the proportion of humus, for if there be very much only true saprophytes (see below) or plants with mycorhiza are able to do well on it. The depth of the soil and its conductivity to heat, and many other factors, also take part in the problem.

Biological Agents are those causes of limitation of specific areas which depend upon the interaction of living organisms with one another. Parasites can only spread with their hosts, saprophytes only where there is plenty of suitable humus, *i.e.* usually only where there are woods of certain kinds of trees; climbers with a few exceptions can only go where there are erect plants or other supports; many plants depend upon insects to a greater or less extent, and the distribution of the latter affects that of the plants (see p. 94), and so on.

Discontinuous Distribution; Geological Influences. A species having arisen upon any area will tend to spread over that area, but whether it ultimately covers it all or not will depend upon the various agents enumerated above. Many species have an enormous range, *e.g.* from Britain to Kamtschatka, others only a restricted one. A species becomes rarer and rarer towards the limit of its area, if this be determined by general climatic conditions, but may be as numerous at the limit as within the area if the limit be a natural barrier. As it spreads over a large area a species will often give rise to new varieties or to new species, and thus a genus will be formed, occupying a larger area than any one of its species, but nevertheless a continuous area. The same reasoning applies to a group of genera, or a natural order. How then does it come about that so many species, genera, and orders occupy disjointed areas at the present time, *e.g.* the Canellaceae, Hamamelidaceae, Styracaceae, Angelica, Bystropogon, Cedronella, Cedrus, Chiogenes, Desmanthus, Epigaea, Eriocaulon, Neotinea, Pachysandra, Shortia, &c. (see Part II.)? Again, how does it happen that many species are common to the various ranges of mountains in each temperate zone, yet do not occur in the intervening lowlands? and how is it that certain forms occur in temperate regions of both Europe and North America, though the bulk of the flora is so unlike in the two cases, and there is no possibility of an 'accidental' transport over such a distance? Accidental transport may account for a few cases in which the species-area is not very much disjointed, but will not explain the occurrence of many Japanese genera in atlantic America, or other such cases. It is possible that in some cases the group or genus under consideration is polyphyletic (p. 29), the different phyla having arisen in different regions from species already separated in space[1]. Again, as a species or family passes its zenith and begins to dwindle, the area occupied by it will

[1] Willis, *Podostemaceae*, Ann. Perad. 1, 1902, p. 448.

be quite likely to become broken into separate portions but this too is not an explanation of many of the cases quoted. The results of geological science must be summoned to our aid. By their help many of the problems can be solved, and botanical geography can in its turn render useful assistance to the geologist, by pointing out former connecting lines, along which species were formerly continuous or were at least able to migrate. Subsidence may break a continent up into islands, and thus a species that formerly occupied the large area may become disconnected and form the starting point of new species, which taken together form a genus. Or again, elevation may unite islands to continents and cause a mingling of floras, or may form mountain-ranges, which act as barriers. Smaller geological changes than these are sufficient to cause changes of the climate, and thus of the flora, of a region.

The higher groups of plants appear to have developed in comparatively recent times—during the Tertiary period of the earth's history. At first the climate seems to have been warm, and subtropical forms extended even into the northern polar regions. Gradually the climate grew colder, and species suited to these conditions appeared in the north and gradually followed the tropical plants southwards, ultimately giving rise to our present temperate flora; as the cold increased, actual arctic species appeared. In the far north the land is continuous or nearly so right round the globe, and many arctic species are circumpolar in distribution at the present day. The similarity of the floras of temperate Europe and North America above-mentioned is usually ascribed to the earlier period when these plants were circumpolar; they were then gradually driven south and gave rise there to new forms. Later in the Tertiary period came the Glacial Era; the cold spread southwards, driving the tropical plants mostly into the southern hemisphere; in what is now the northern torrid zone a subtropical flora probably occurred, whilst arctic species came southwards over America and Europe to the latitude of the Pyrenees. Afterwards, as the cold retreated, these various northern plants were driven back again by the advance of the southern vegetation, but besides going northwards they would also go up the mountains as new and suitable territory became available at higher and higher levels. This explains how so many northern forms occur on the mountains of the tropics, and so many arctic genera on those of Europe, and also why there are so many species identical on the different European and even American mountain-ranges, these being in fact species derived from the arctic region in the glacial period.

Island-Floras[1]. The flora of such an island as Great Britain, recently detached from a continent, is much like that of the continent; but in true oceanic islands, such as the Sandwich Islands, the Canaries, the Azores, St Helena, &c., the flora is peculiar, containing a considerable proportion of endemic forms; a study of these floras has led to many important conclusions upon migration, distribution, &c. The endemic forms are sometimes of specific rank only, in which case it seems probable that the isolation of the island cannot have lasted very long, or that it cannot have been long inhabited by plants; sometimes of generic rank (*e.g.* see Bencomia, Brexia, Commidendron, Lodoicea, &c.), and in one case (*Lactoris fernandeziana* from Juan Fernandez) even of ordinal rank. They illustrate the important conclusion that geographical isolation involves the production of new forms. The most striking examples of this are seen in such archipelagos as the Galapagos Islands, where almost every island has its own endemic species.

The flora of an island may be derived from many sources; islands detached from continents begin with a flora like that of the continent, whilst islands formed by volcanic agencies or coral-animals begin with no flora and become gradually occupied by plants with dispersal-methods capable of transporting their seeds to it. Thus in the island of Krakatoa, which was completely denuded of vegetation by the eruption of 1883, small algae and ferns were first to arrive, and then coast-plants and those distributed by birds. Besides the more modern forms, such islands as the Azores possess many plants whose presence probably dates from far

[1] Wallace, *Island Life*; Hemsley, *Botany of Challenger Expedition*, vol. 1, 1885; Schimper, *Die indomalayische Strand-flora*; Treub in Ann. Buitenz. 1, VII. Penzig in do., 2, III. on *Flora of Krakatau*; Willis and Gardiner, *Botany of the Maldives*, Ann. Perad. 1, 1902, p. 45.

back in Tertiary times; these have been able to survive on the islands with little or no modification, whilst they have disappeared from the continental areas. The number of species in island-floras is usually small and the struggle for existence among them probably less keen and complex, and thus not merely have old forms been enabled to survive, but the adaptation of the various plants to their environment is not very perfect. This is shown by the way in which introduced species from large continental areas spread over islands at the expense of the indigenous flora. A large number of European plants are naturalised in most oceanic islands, and many of the native forms have become rare or extinct, *e.g.* in St Helena and even in such large islands as Australia and New Zealand.

The floras of oceanic islands generally show a large proportionate representation of orders and genera. Woody or subarboreal habit is common; also the possession of small, narrow leaves. Flowers are commonly small and inconspicuous (see Pringlea).

Mountain-Floras[1]. Mountain regions may be compared with islands, the higher parts differing so much in climate &c. from the lower parts and the lowlands from which they rise as to form isolated regions in which new forms may be evolved. With few exceptions all the higher mountain ranges are characterised by the possession of numerous endemic species and genera. The mountains of Britain, Scandinavia, Kamtschatka, &c. do not show this character. Their flora resembles that of the arctic regions, having been derived from it during the glacial period. In the Pyrenees, Alps, &c., though there are many arctic forms, there are many endemic genera and species.

We have already pointed out that mountain chains act as highways of migration (as do railway-embankments on a small scale). The universally American character of the floras of the different parts of America from north to south is probably in part to be ascribed to the long chain of the Rocky Mountains and the Andes, which has formed a

[1] Engler, *Die Pflanzenformationen...d. Alpenkette*, Notizbl. k. Bot. Gtns., Berlin, Appendix VII, 1901; Jaccard, *Gesetze d. Pflanzenvertheilung in d. alpiner Region*, Flora, 90, p. 349; and see Alpine Plants, below.

highway for migration. The general characters of Alpine plants are dealt with below.

Forms of Vegetation. We shall now deal briefly with the morphology and natural history of a number of important *forms of vegetation.* By this term we understand groups of plants, belonging to various natural orders, but presenting a general resemblance in their external habit, often correlated with resemblance in the conditions of life.

According to the particular ecological character upon which we lay most stress, we may divide plants into groups in various ways, *e.g.* by differences in habit into trees, shrubs, and herbs; by different relations to water supply into hydro-, meso- and xero-phytes; into erect plants, creepers, climbers, and epiphytes, and so on.

Herbs[1]. According to their general habit plants may be roughly divided into *trees*, *shrubs*, and *herbs*; the last are plants which do not possess any woody stem above ground, but are made up of softer tissues, and usually die down to the soil in autumn or after flowering. It is difficult to draw the line between herbs and shrubs; such plants as the wall-flower, the base of whose stem is woody and persistent, may be termed *suffruticose* herbs. Many herbs are of great size, *e.g.* the agave, the banana (Musa), Amorphophallus, &c. All the Thallophyta and Bryophyta are herbaceous, and most existing Pteridophyta, though many fossil trees are known. In the Angiosperms the majority of species are herbaceous, and especially those of the higher orders (p. 121).

Herbs may be *annual*, *biennial* or *perennial*; in the first case the entire life-history from germination to the ripening of the seed is carried out in one year. Some, *e.g.* *Stellaria media*, go through several generations in one year, and may be termed *ephemeral.* In an annual plant there is no need for any storage of reserves except in the seeds; the materials formed in the leaves are used directly in growth, flower-formation, &c. Correlated with this is the fact that the flowers are not as a rule very large or conspicuous (such flowers require much material for their formation); most

[1] Goebel, *Organography of Plants*; Areschoug (*Geophile Pflanzen*) in Acta Reg. Soc. Phys., Lund 1896; Vöchting (*Knollengewächse*) in Prings. Jahrb. f. wiss. Bot. 32, 1899; Freidenfelt (*Wurzeln krautiger Pflanzen*) in Flora, 91, 1902.

annuals are proletarians (p. 59). It is absolutely essential to the continuance of the race that plenty of seed should be set, and as a rule the flowers do not possess such mechanisms as risk in any degree the fulfilment of this end; most are capable of self-fertilisation, and many are rarely if ever crossed. Vegetative reproduction is rare.

In biennials, *e.g.* the carrot (Daucus), turnip, cabbage, kohl-rabi (Brassica), beetroot (Beta), parsnip (Peucedanum), &c., the case is different, and much storage of reserves takes place. During the first year the plant does not as a rule produce a tall stem or an inflorescence, but has usually a rosette of large radical leaves. The food-materials produced in these exceed the immediate requirements of the plant and the balance is stored up in the root, stem, or leaves which become thick and fleshy. The plant remains quiescent (*hibernates*) during the winter. Next spring a tall stem is produced, consisting chiefly of an inflorescence, and when the seeds are ripe the plant dies. Practically all the food required during the second year is derived from the reserve-stores, which become completely exhausted. An exaggeration of this feature of biennials—the storage of reserves to be used in a single flowering—leads to the peculiar cases of Agave and Furcraea, &c., which save up materials for many years and use them all in one great burst of flowers at the end.

In perennial herbs, which live for several or many years, and usually flower each year, the vegetative period is generally interrupted at regular intervals, either by winter, or by the dry season in hot countries; the plant then as a rule dies down. Hence there must be a storage of reserves, to enable the plant to recommence its growth upon the return of spring (or the rainy season). This storage is usually made below ground, where it is well protected, and may be in the root, stem, or leaves. The part in which storage is made is more or less swollen, and if it include a bud is nearly always made to subserve the process of vegetative reproduction (p. 112). In many cases the original plant does not reappear in the second season, but a number of new plants formed from it by vegetative methods appear in its place.

In many Liliaceae, *e.g.* onion or lily, and other plants, there is a modified shoot termed a *bulb*. It consists of a small disc-like stem at the base, bearing a more or less spherical mass of leaves above, these being closely folded over one another and swollen with reserves; the leaves in an onion or hyacinth completely enwrap the bulb, which is said to be *tunicated*, whereas in the lily they merely overlap one another and the bulb is *scaly*. The outermost leaves of a tunicated bulb are usually thin, dry, and membranous, protecting the fleshy leaves. In the centre of the bulb the discoid stem is prolonged into the short inflorescence-axis. Roots are developed adventitiously from the lower side of the stem. It is evident that a bulb is simply a large bud with fleshy leaves. When it sprouts in spring or in the rainy season, it produces an inflorescence and some green leaves (borne on the same axis as the flowers, or springing from the tops of the bulb-leaves) at the expense of its reserves. After the seeding is over the leaves continue to assimilate, and new reserve-stores are formed, but not in the original bulb. In the axils of the leaves buds are formed, and into these the reserves are carried, and the buds gradually enlarge into 'daughter-bulbs' within the parent-bulb. Then when the latter dies down the new bulbs remain in its place.

Another type of shoot is the *corm* or 'solid bulb,' as seen in Crocus, Cyclamen, Colchicum, Eranthis, Bowiea, Testudinaria, &c. The lower part of the stem, at or below the level of the soil, is swollen out into a more or less spherical shape to contain reserve materials. At the top is the bud, which in the vegetative period forms the leafy shoot at the expense of the reserves. In many cases new corms are formed as branches on the old ones and the latter have usually only one year's activity; the branches may be on top of the old corm (Crocus) or at the side (Eranthis, Colchicum). In other cases (Bowiea, Hablitzia, Testudinaria, &c.), the corm is perennial, and a new leafy shoot arises each year from the top of it, usually in the axil of a leaf of the preceding year. The corm is often (*e.g.* in Crocus) covered outside by a few membranous leaves, so that it looks like a true bulb till cut in section. The corm is simply a variety of the stem-tuber. The name *tuber* is given to any swollen part of a plant in which reserves are stored up, except bulbs or leaves. The tuber may be of stem or root nature. In the former case it usually forms the termination of a special lateral branch, which grows out horizontally and swells up at the end. Underground tubers occur in potato (Solanum), artichoke (Helianthus), Ullucus, &c.; they betray their stem nature by their axillary origin (p. 41), and by bearing leaves reduced to scales, in whose axils buds ('eyes') are formed. These tubers subserve vegetative reproduction; the connecting branches die away and the eyes sprout out into new plants at the expense of the reserves. The main stem forms tubers in the cases of corms already mentioned, and in Dioscorea, Basellaceae, Tamus, epiphytic Orchidaceae, &c. Roots swollen into tubers occur in Dahlia, Thladiantha, Dioscorea, Bravoa, Paeonia, Uragoga, &c. In Orchis and other terrestrial orchids a bud forms in the axil of one of the lowest leaves; upon it is developed an adventitious root which grows into a tuber with the bud at its apex; this hibernates and grows out next year into a new plant, and so on. In dandelion (Taraxacum), Monotropa, Linaria, &c., the main root is fleshy and each new annual shoot arises at its summit, sometimes in the axil of one of the leaves of the preceding year, sometimes as an adventitious bud.

Other plants store reserves in underground creeping stems or *rhizomes*. These are usually thickened; their leaves are reduced to scales, being useless for assimilation purposes. In a few cases the rhizome is monopodial (p. 42) and the leaves appear above ground, the stem remaining below, as in Pteris, but as a rule the rhizome is sympodial and each year's shoot is of an L shape, its upper end appearing above ground and producing green leaves. Rhizomes often branch largely, and as the older parts decay the branches are set free and thus vegetative multiplication occurs. Good examples are seen in Iridaceae, Juncus, Musa, Dioscorea, Cyperaceae, Oxalis, Helleborus, Sanguinaria, and many other plants. In some cases the rhizome instead of creeping horizontally stands more or less erect and resembles a tuber; in such cases it is usually termed a *root-stock*, *e.g.* Aspidium (monopodial), Primula (sympodial). All these types graduate into one another imperceptibly.

Other shoots occur whose chief or sole function is vegetative reproduction, rather than hibernation. In Gesneraceae, short rhizomes or *suckers* are formed as branches which turn up at the end and form new plants; these ultimately become detached from the parent plant. Creeping stems (*runners* or *stolons*) occur above ground in many plants; they are usually formed as axillary branches on the main stem near the base; they grow along the soil and take root at the nodes, and the axillary buds at the nodes form new plants, *e.g.* in the strawberry (Fragaria), Ranunculus sp., Agrostis, Agropyron sp., Epilobium sp., Nephrolepis, Ajuga, and others. In Glaux, Samolus, Nasturtium, &c., new shoots are formed and take root, but can hardly be called runners. The short runners of Sempervivum, Agave, &c., which bend up at the ends into new plants, are called *offsets*. Vegetative reproduction is also common in the upper part of the stem, especially in the inflorescence portion, where some or even all of the flowers are replaced by bulbils, &c. (see p. 113).

Bud-protection (p. 41) is exhibited in many forms in herbs. Those which have to survive a winter usually have their buds, as we have just seen, upon underground parts, and thus little further protection is required; this is given by the formation of scales (modified leaves or stipules) on the outside of the bud. Xerophytes and tropical plants, which require protection against drought and heat, are dealt with below.

Protection against grazing animals is obtained in many herbs by aid of stinging hairs (Urticaceae, Loasaceae, &c.), prickles, spines, &c., or by the presence in the tissues of poisonous or distasteful substances. These also act as protection against snails, caterpillars, &c.[1] Glandular hairs also probably act as protections of this nature.

Shrubs and Trees[2] are perennial plants with woody stems above ground, and do not entirely die down during the period when vegetation is interrupted. Shrubs are described as woody plants of not more than about 30 feet high, and much branched down to the level of the ground, whereas trees have usually one stem at the base which branches out above, and generally grow to more than 30 feet in height. A sharp demarcation cannot be made, all kinds of intermediate forms existing. Similarly between shrubs and herbs there occur intermediate forms; low-growing shrubby plants like heather (Calluna) are termed *under-shrubs*, and below these are suffruticose herbs (above).

A large proportion of the earth is covered with trees and shrubs; in the colder parts of the north temperate zone these are mostly Conifers, elsewhere Angiosperms, or sometimes Ferns. Forests grow best where there is plenty of moisture, as in the tropical monsoon region, the Amazon valley, and the lower slopes of mountains.

The majority of trees and shrubs are *evergreen*, retaining their foliage throughout the year; others are *deciduous*, dropping their leaves in autumn or at the beginning of the dry season. In temperate climates the evergreens are chiefly Conifers, and the other woody plants are deciduous. The former are of monopodial growth, and when growing apart from other trees are of more or less conical shape, with branches from top to bottom; in forests the lower shaded branches die and fall away and the tree spreads out at the top only. The deciduous trees usually show a more rounded shape when growing separately (*e.g.* elm or oak), and they do not generally show a single straight main stem reaching right to the top (*excurrent*) as in pines, but their stems are more or less broken up into branches (*deliquescent*) at some height from the ground. Most of

[1] Stahl, *Pflanzen und Schnecken*, Jena, 1889.

[2] Areschong, *Beitr. z. Biol. d. Holzgewächse*, Lund, 1877; Goebel, *Organography of Plants;* Potter (*Bud-protection*) in Linn. Soc. J., 1888; Keeble (*Hanging Foliage*) in Ann. Bot., 1895; Stahl (*Regénfall u. Blattgestalt*) in Ann. Buitenz., 1893; Groom (*Bud-protection*) in Linn. Soc. Trans., 1893, &c.; and see below.

them are of sympodial growth. In tropical regions most trees are evergreen. Two chief types occur, those with branched stems and those with columnar usually unbranched stems. The former branch in the ordinary way, but their branches very often grow almost erect and parallel, instead of spreading out in all directions, and the leaves are borne in rosettes, or tufts at the ends of the twigs. The latter are best illustrated by the Palms, many Araliaceae, Cycads, &c., with an erect trunk bearing a rosette of large leaves. Both forms are excellently suited to growth in forests, their leaves thus being all exposed to light at the top of the tree. In the dry climates of the sub-tropical regions, many deciduous trees and shrubs are found, the leaves falling at the beginning of the dry period.

The woody plants of temperate climates form *winter-buds* (often even when evergreen, as seen in Rhododendron, &c.) at the ends of their branches in autumn; these contain all or part of the next year's growth in a more or less developed condition. The bud is exposed to evaporation, cold, wet, and other dangers, but is protected in most cases by scales; these are sometimes modified leaves, as in Acer, Aesculus, &c., sometimes the stipules of the outer leaves, as in Magnolia, Bucklandia, &c.; in some cases the scales are hairy, in others glandular or resinous, so that they form an efficient protection. In Juglandaceae, Viburnum, Sophora, &c. the winter-buds are not protected by scales, but their leaves themselves are more or less hairy or otherwise protected. Many winter-buds are able to absorb water from rain, and this helps them to recover their losses by evaporation at a period when the roots are not active.

In spring the winter-buds elongate, casting off their scales; the large buds of horse-chestnuts, pines, and other plants grow rapidly to their full elongation and then stop, so that the growth is *definite*, while in Rosa, Salix, Gleditschia and many other plants the growth continues till checked by the cold (*i.e.* is *indefinite*), the terminal part of the shoot dying and the new growth in spring starting from a lateral bud. In lilac (Syringa) and other plants the terminal bud regularly aborts and growth starts from the laterals in the succeeding year. The lateral buds in Robinia, Platanus, &c. are protected in summer by the bases of the leaf-stalks. Flower-buds also are often laid down in autumn, as seen in Prunus or Rhododendron.

The same principles apply to the resting-bud formation in desert plants, &c. The reserves necessary for the re-starting of growth are usually stored in the living cells of the stem.

The winter-buds of most trees and shrubs have characteristic sizes, shapes, colours, &c.; tables have been constructed for the determination of their genus and species from these characters[1].

The fall of the leaves is usually affected by the formation of an *absciss layer* at the base of the stalk, cutting off the leaf-tissues from those of the stem by a development of cork (bark). This splits down the middle and leaves one half upon the stem, where it forms the *leaf-scar* covering the wound. Leaves thus cut off are termed *articulate;* those not thus cut off are *non-articulate*, as in the oak, whose leaves remain hanging upon the twigs most of the winter. The formation of the absciss layer is a definite vital phenomenon; broken branches, being deprived of their water supply and thus killed, do not form absciss layers.

Whilst in herbaceous plants all or most of the branch buds usually develope at once, this is not the case in trees. A number of the buds remain dormant and start into growth if the others be injured. Adventitious buds are often formed on the stems of trees and give rise to the leafy twigs seen on the trunks of elms, &c., and to the flowers borne on the trunks of many tropical trees, *e.g.* Ficus, Theobroma, Averrhoa. The *witches' brooms* so often seen in birch and other trees—bird's-nest-like bunches of twigs—are due to adventitious branching stimulated by the growth of a parasitic fungus (Aecidium) in the stem. Similarly the crown of branches of a pollard ash or willow arises from adventitious buds formed at the cut surfaces. At a wounded surface the cambium or formative tissue gives rise to a mass of *callus*, new cellular tissue covering the wound, and in this buds may develope.

[1] Plüss, *Unsere Bäume und Sträucher*, Freiburg, 1894; Schneider, *Dendrologische Winterstudien*, Jena, 1903; Walser, *Der Baum im Winter*, Bern, 1894; Foerste in Bot. Gazette, 1892.

The evergreen trees and shrubs of the damper tropical regions do not form true resting-buds but vegetate all the year round, though commonly exhibiting a regular periodicity in the unfolding of new leaves, flowers, &c. The buds of young leaves require more or less protection from radiation and the accompanying dangers of too rapid evaporation or decomposition of the chlorophyll. A very frequent protective feature noticed in tropical plants is the red colour of the young leaves, well seen in Cinnamomum, Haematoxylon, &c.; as the leaves get to their full size the chlorophyll developes. The young leaves commonly hang downwards, so that they receive less radiation, and straighten up as they become mature, *e.g.* in Bauhinia, Dryobalanops, Cinnamomum and many others; this may also be seen in Aesculus and other temperate plants. In Brownea, Amherstia, &c., the whole young shoot droops. In Artocarpus, Dipterocarpus, Ficus, &c., the stipules protect the bud; in Manihot the petioles of the young leaves curve upwards and inwards over the bud; in Tabernaemontana the bud is protected by the bases of the older leaves, which secrete a resinous substance, and so on.

Many trees flower only at intervals, when they have saved enough reserve-materials to supply the flowers and seeds (*cf.* Agave, above). The beech is an example among deciduous trees; others are Bambusa, &c., and Corypha and other palms which only flower once and then die.

As their height increases, most shrubs and trees grow also in thickness, usually by means of the cambium layer in the vascular bundles, which adds new wood to the outer side of that already existing, and new phloem to the inner side of the old phloem. In the great majority of trees, a cross section of the trunk shows distinct *rings of growth* in the wood, due to contrast of texture in the new wood formed at different times. In temperate climates the contrast is between autumn and spring wood, and the ring may be termed an *annual ring*, one being formed each year of the tree's life. In tropical climates with two wet seasons a year, many trees form two rings annually; others form rings only when they drop their leaves and form new ones, and so on. In dry subtropical climates, the contrast is between early dry-season and early wet-season wood. The phenomenon is correlated largely with contrasts in the amount of transpiration going on.

Only the recent wood is employed in the carriage of water up to the leaves; this, with the watery wood of the year or two preceding it, is termed the *sap-wood* or *alburnum* in contradistinction to the older *heart-wood* or *duramen.* The outside of the stem is covered by the *bark*, a corky layer formed by a special formative tissue or *phellogen*; between it and the wood lie the phloem and cambium.

Water-Plants[1], or *hydrophytes*, are a very well-marked form of vegetation, contrasting with xero- and meso-phytes. Close similarity in the conditions of life seems to have determined, amongst plants belonging to various different families, a remarkable resemblance in general habit and structure. In few cases can we so satisfactorily determine which of the peculiarities with which we have to deal are really adaptations to the mode of life.

Primitive water-plants, *i.e.* those which have no land-forms among their ancestry, probably do not occur in the higher groups of plants with which this book deals; probably these are almost undoubtedly descended from land-forms, as is indicated by their possession of flowers adapted (in most cases) for pollination by wind or insects, and by many facts in their morphology and anatomy. They perhaps began as marsh plants and were gradually driven into purely aquatic existence by the necessities of the struggle for existence. The date at which the ancestral forms became aquatic may have been comparatively recent or very far back. In the latter case we find entire natural orders composed of water-plants, as Ceratophyllaceae, Naiadaceae, Podostemaceae. In the former, we have instances like Hottonia in Primulaceae, of one or two aquatic genera in a family, or the water Ranunculi, where it is one or two species in a genus. The modification of structure to meet the changed conditions of life seems also to have progressed,

[1] Schenk, *Die Wassergewächse*, Bonn, 1886; *Anatomie der submersen Gewächse* (Bibl. Bot.); Goebel, *Pflanzenbiologische Schilderungen*; Schimper, *Pflanzengeographie*; Warming, *Oekologische Pflanzengeographie*; Willis, *Morphology and Ecology of the Podostemaceae*, Ann. Perad. I., 1902, p. 267.

as a rule, more or less far according to the presumable length of time the plants have been aquatics. In the case of the orders first mentioned, a study of the classificatory details will show how hard it is even to decide upon their approximate position in a natural scheme of classification. In the case of Ranunculus, Potamogeton, and others, the variability is enormous and leads to great difficulty in the determination of species, comparable to the cases of Rubus, Hieracium, &c. These plants having only recently commenced their evolution into aquatics, it has not yet, perhaps, become complete.

In general the conditions of water life are far more constant and uniform all over the world than those of existence on land. Accordingly the few species of spermaphytic water-plants have a far wider distribution than land-plants. Most of the British forms are found throughout the north temperate zone. In the tropics other forms occur, which vegetate continuously the year round. In the temperate zones, on the other hand, hibernation is necessary, and may occur in a variety of ways.

Ruppia, Zannichellia, Callitriche, Ceratophyllum and many others remain unaltered, though often sinking to the bottom of the water. Nymphaeaceae, *Potamogeton natans*, &c., hibernate in the form of rhizomes, stored with reserves to start growth in spring. *Potamogeton pectinatus*, Sagittaria, &c. form special tubers, something like the potato. A large number form special winter-buds—large buds at the ends of the stems, with a great number of closely packed green leaves provided with reserve food-stuffs. These usually drop off and spend the winter at the bottom of the pond, coming up and expanding in spring. Such are Utricularia, Hottonia, Myriophyllum, Hydrocharis, *Potamogeton crispus* and other species. More or less unique methods of hibernation occur in Lemnaceae, &c. (*q.v.*).

Owing to the high specific and latent heat of water a water-plant is less exposed to violent changes of temperature than a land-plant, and if there be plenty of water is not liable to be interrupted in its growth by a drought in summer. These conditions favour its vegetative growth considerably, and it is still more aided by the peculiar conditions of nutrition. It takes in all or most of its food in solution from the water, which contains, owing to the difference in solubility of the two gases, more carbon dioxide and less oxygen in proportion than does the air. As the latter contains more oxygen than is needful, and less carbon dioxide than would be most advantageous to vegetation, the water-plant is highly favoured. Correlated with these things is the rapid growth, frequent branching, and extensive vegetative reproduction exhibited. This last occurs to some extent in the formation of several winter-buds or tubers on a single plant; it happens also by the decaying away of the older parts of stems and the consequent liberation of the branches seen in so many water-plants, or even by the breaking off of twigs by currents of water or otherwise (as in Elodea), and in other ways.

Correlated with the fact that all submerged parts absorb fluid directly is the absence of cuticle on the surface and the branching of leaves to expose a large area, while owing to this and to the fact that there is no transpiration in submerged plants, there are few or no stomata and little or no water-carrying xylem tissue present, and the root, deprived of one of its great functions, is most often either absent or much reduced, serving only for anchorage.

Again, mechanical influences come into play. An ordinary stem or leaf requires a quantity of "mechanical tissue" (fibres) so disposed as to resist the stresses caused by weight, wind, and so on. In a water-plant the weight is upheld by the water and there is no need for mechanical tissue, nor do we find it. What little strain there is on the stem or leaf is usually longitudinal, and the vascular bundle (the strongest tissue of the plant) is axially placed, as in a land-root, to resist it. The leaf exhibits four main types, according to the conditions under which it lives, viz. (1) the ribbon type, (2) the much-divided type, and (3) the awl-shaped type in submerged leaves, and (4) the floating type. The first is seen in most Monocotyledons, *e.g.* Vallisneria, Glyceria, Potamogeton sp. &c.—the narrow leaf drifting with the current in the form of a long ribbon. The much-divided leaf, with linear segments, offering little resistance to the movement of the water, is seen in Ranunculus, Cabomba, Trapa, &c.; special patterns that also belong to this class are the leaves of *Aponogeton fenestralis* and others. Hippuris may form a link between this group and the preceding. The awl-shaped leaf is found in Isoetes, Subularia, Lobelia, &c.; most of these plants are able to grow on dry land, usually in other forms more suited to land-existence (p. 20). The floating leaf, as seen in Nymphaeaceae, Trapa, Ranunculus sp., &c., is usually large, entire or nearly so (a divided leaf would be easily submerged, or at least wetted so as to interfere with its functions), of leathery consistency and usually of oval or circular outline. The stalk is capable of renewing its growth should the leaf be submerged, so as to bring it back to the surface. The upper surface of such a leaf is provided with cuticle (often waxy), palisade-tissue and stomata, and functions like a land-leaf.

Another determining factor is light. Water absorbs it to such an extent that submerged plants are practically shade-plants (p. 142) and exhibit similar features. The internodes are long (etiolated; *cf.* climbing plants, below), the leaves are usually thin and have no palisade-tissue, and the cells of the epidermis contain chlorophyll.

A very characteristic feature is the presence of enormous intercellular spaces, giving the tissues a spongy consistency easily visible to the naked eye. They are full of air and probably serve more than one function; they act as floats to the plant, they probably aid in the assimilatory functions by supplying gases to the cells, and they seem to act as channels by which oxygen can reach those parts of the plant which are in deep water or in mud, where there is little or no oxygen for respiration. In Podostemaceae, which live in rapids attached to rocks, and consequently have all their parts exposed to well-aerated water, the large air-spaces are entirely absent, while in marsh-plants they are usually strongly marked. Secondary respiratory tissue (*aerenchyma*), formed by the phellogen layer, is frequently found in plants growing in mud or nearly stagnant water, *e.g.* in roots of Sesbania and Jussieua, stems of Neptunia, &c. It is also said to occur on submerged parts of Lycopus, Lythrum, and other mud-plants (*cf.* also Rumex). In many mangroves, Taxodium, &c., special erect roots are formed, with stout aerenchymatous tissue; they appear to be respiratory organs, and are sometimes termed *pneumatophores*.

One of the most common structural peculiarities of water-plants, whether Algae or higher plants, is their sliminess. In the flowering plants it is usually due to a secretion of mucilage by glands or hairs upon the surface. Its presence renders diffusion more slow and is probably advantageous in this way, by preventing the too rapid escape of the substances dissolved in the cell-sap into the surrounding water.

Most water-plants are perennials; annuals occur in the genera Naias, Subularia, Marsilea. Many Podostemaceae, though usually annual, may become perennial if not exposed in the dry season.

The great vegetative growth and multiplication of water-plants is accompanied as usual (p. 113) by a reduction of the flowering activity (but *cf.* Podostemaceae which combine the two). Many species flower rarely, and few flower as profusely as land-plants. Most species display their flowers above the water for pollination by wind or insects. The mechanisms resemble those of ordinary land-plants, but the flowers are rarely successful in setting much cross-fertilised seed, for they are so close to the water that much of the pollen of the anemophilous species falls into the water and is wasted, and insects are few and far between so that the entomophilous species are not much visited. A few plants, *e.g.* Elodea and Vallisneria, display a modification of their floral structure adapted to pollination at the surface of the water, and in Ruppia, Zostera, &c., pollination takes place under water and the floral structure is highly modified.

The fruits are usually achenes, nuts, or schizocarps, and are nearly always ripened under water; some plants, *e.g.* Vallisneria, have special arrangements for drawing them down to ripen (*cf.* Cyclamen). The seeds (or fruits) usually sink in water, but some plants have arrangements by which they may be kept afloat for a time and thus dispersed to a distance (see Nymphaeaceae, &c.). The germination of the seeds often furnishes interesting features—leaves differing from those of the mature plant, special adaptations, &c.

The same plant may often grow at different times under different conditions and exhibit different structural features and habit. Many plants which usually grow in marshy places are able to grow submerged in water, and frequently the land and water forms differ, *e.g.* in Littorella, Polygonum sp., &c. Such plants may be termed *amphibious*. The most fully adapted water-plants such as Myriophyllum, Vallisneria, Zostera, &c., are not capable of living upon land.

Heterophylly (p. 50) is a frequent phenomenon in water-plants; the most common case is the production of swimming and submerged leaves of different patterns, *e.g.* in Cabomba, Callitriche, Potamogeton sp., Ranunculus sp., Sagittaria, Salvinia, Trapa, &c.

Most water-plants live in comparatively quiet water, but in the tropics there is a very interesting family, the Podostemaceae, living in swiftly moving water, in rapids and water-falls, where they cling to the rocks like seaweeds on a rocky coast. As might be expected, they show a very peculiar structure; they differ from other water-plants in the absence of intercellular spaces, and in their possession of a *thallus*. The seeds lie about on the rocks in the dry season, and germinate in the rainy season when submerged; the thallus arises from the primary axis and is sometimes of shoot, sometimes of adventitious root nature. It is fastened to the rocks by root-hairs and by special holdfasts or *haptera*, and upon it arise numerous secondary shoots, upon which the flowers are ultimately developed, opening when the fall of the water in the dry season exposes them to the air. The exposed plants soon die. These plants show the most remarkable structural dorsiventrality among the higher plants.

For further details reference should be made to Part II., articles Aldrovanda, Alismaceae, Aponogeton, Azolla, Bidens, Cabomba, Callitriche, Ceratophyllum, Eichhornia, Elodea, Jussieua, Lemna, Littorella, Limnanthemum, Myriophyllum, Naias, Nelumbium, Nuphar, Nymphaea, Nymphaeaceae, Peplis, Pistia, Podostemaceae, Potamogeton, Potamogetonaceae, Ranunculus, Rumex, Ruppia, Sagittaria, Salvinia, Sesbania, Stratiotes, Subularia, Trapa, Vallisneria, Victoria, Zannichellia, Zostera, &c.

Xerophytes[1]. In such a climate as that of the lowlands of western Europe, everything in the structure of the leaf, the phyllotaxy, branching, &c., is so arranged as to favour transpiration to the utmost, and thus to cause a rapid current of water from the roots to the leaves. So long as the roots can absorb plenty of water this form of

[1] Schimper, *Pflanzengeographie*; Warming, *Oekologische Pflanzengeographie*; Volkens, *Flora der aegyptisch-arabischen Wüste*; Goebel, *Pflanzenbiologische Schilderungen*.

plant-organisation is excellent, and favours rapid growth. But if the roots are not able to absorb water at all times fast enough for so much evaporation, it is evident that a reduction of the transpiration is a prime necessity of life, and that plants in which this is effected will be most suitable to such a position or climate. These conditions occur in many places—in countries with long dry seasons when the water supply runs short, in arctic and high mountain regions where everything favours transpiration (see below) and the coldness of the soil checks absorption, in sandy or rocky soils, upon sea-shores or in salt steppes where the presence of salt in the soil renders absorption difficult, in epiphytic situations (see below) and also in winter when the soil is too cold for absorption. In all such places the plants show a remarkable general similarity, and agree in having a lower rate of transpiration than plants living where there is plenty of available water. Plants of this kind are termed *xerophytes.*

As so often happens, a compromise has to be made between opposing necessities—the need of reducing evaporation, and the need of vigorous assimilation. The structural features that favour transpiration favour assimilation also, and the reduction of the former tends to be accompanied by that of the latter function. Every possible compromise may be seen in the variety of structure found in xerophytes.

All round the world, in the sub-tropical regions, there are vast areas in which there is a long rainless season in the year, *e.g.* the Mediterranean region, Arabia, the Steppes of Asiatic Russia, the desert of Gobi, the southern prairies of North America, Mexico, Peru, Chili, the Pampas, much of South Africa and Australia. In all these regions xerophytes occur, their degree of adaptation depending on the length of the dry season. If the drought be not very prolonged, many are able to survive by the mere reduction of the transpiration, but if it be extreme, or last for a long period, water is stored up to enable the plants to survive, and they are more or less fleshy in structure. In this case other materials are often stored also, and vegetation stops during the drought, to be resumed with the wet season.

An almost universal feature in xerophytes is a thick cuticle upon the epidermis of the leaf. The leathery texture of the leaves of many xerophytes is partly due to the thickness of their cuticle. The number of the stomata is commonly much reduced, and also the size of the intercellular air-spaces in the leaf; therefore evaporation is lessened. Instead of being flush with the surface the stomata are commonly sunk at the base of small pits in the leaf, into which the wind cannot enter, and which therefore become filled with saturated air, thus reducing transpiration. In Pinus, Aloe, and many xerophytes there is a separate small pit for each stoma, but in Nerium and others the pits are large and contain several stomata. A somewhat similar arrangement on the large scale is seen in the grooves of such leaves as those of Empetrum, Vaccinium sp., Phylica, Cassiope, Rosmarinus, or such stems as those of Casuarina, Spartium, Cacti, &c., the stomata being at the bottom of the furrows. The grooves are more or less covered in in the leaves mentioned, especially in Empetrum; in many of the grasses (*e.g.* Stipa) the leaf rolls up in dry air, completely closing in the stomata, and exposing only the impervious surface to the outer air.

The surface of xerophytes is often closed with a thick covering of hairs, which retard transpiration by preventing the wind from reaching the stomata. This is well seen in the Edelweiss, in many alpine willows, in Stachys sp., *Alchemilla alpina*, Helichrysum, &c. A covering of wax occurs on the epidermis of many Liliaceae (*e.g.* Aloe), Crassulaceae, &c., a covering of silica on that of *Crassula* (*Rochea*) *falcata*. The thick sap of such plants as Aloe is another preventive against excessive transpiration, for it only evaporates very slowly.

Instead of being spread out to the utmost extent the leaves of many xerophytes are closely placed and overlap one another very much, *e.g.* in Gasteria, Aloe, many Crassulaceae, Calluna, &c. The plants often grow in dense tufts, closely crowded together, and thus further reduce the free access of air and check evaporation, *e.g.* in Raoulia and Azorella; this is especially frequent in alpine plants.

Further arrangements for reduction of transpiration usually occur; we shall deal first with evergreens, to which group most xerophytes belong.

The most simple mode of reducing evaporation is a reduction of the transpiring surface, which is very common. The leaves of Hakea sp., Grevillea and other Proteaceae, *Rubus australis*, Russelia, &c., are much branched into fine segments which expose but little surface for evaporation. Comparison with related forms or observation of seedlings shows in most of these cases that a real reduction of leaf-surface has occurred in the phylogeny. In many Ericaceae the leaves are narrow and needle-like, and often more or less rolled back, and this *ericoid* type of leaf is found in many xerophytes, *e.g.* Aspalathus, Epacridaceae, Empetraceae, many Rutaceae (*e.g.* Diosma), Rhamnaceae, &c.; a somewhat similar form occurs in Ulex, and in Pinus and other Conifers. The leaves of Cupressus and other Conifers are reduced to small green scales closely pressed against the stem; this form occurs in many New Zealand alpine Veronicas and in other xerophytes. In these cases the stem usually does some of the assimilation, and a further progress in this direction leads to cases in which all the green tissue is found in the stem and the leaves are reduced to scales, the stems retaining their more or less cylindrical form, *e.g.* in Casuarina, Cytisus sp., Spartium, Baccharis, Restio, Juncus, Ephedra, &c. They are usually grooved lengthwise, and the green tissue and stomata occupy the bases of the grooves. In some species of Baccharis, Genista, and others, the green stems have their assimilating surface increased by the presence of longitudinal wings; this leads on to such cases as Bossiaea, Carmichaelia, Muehlenbeckia, Phyllanthus, &c., with long shoots transformed into flat green expansions (*phylloclades*) which act as leaves, whilst the true leaves are reduced to scales. They occur also in Ruscus, Semele, &c., as short lateral branches, closely resembling leaves (see also Colletia). Standing with their edges to the sky they transpire less than a dorsiventral leaf of similar size.

This advantage of phylloclades—the edgewise position—is also obtained in many xerophytes which possess green leaves. In many tropical Leguminosae, &c., the leaves (or leaflets) move upwards or downwards when the radiation becomes too intense, and thus expose only their edges or at most sloping surfaces to it (p. 49). In Eucalyptus and many other xerophytes the leaves are more or less twisted at the base, so as to place their edges upwards. The *phyllodes* of Acacia (*q.v.*), &c., attain the same end in a different way. Another similar arrangement is seen in the isobilateral leaves of Iris, Narthecium, Phormium, &c. (p. 49).

In addition to the reduction of transpiration obtained by these methods many xerophytes store up water to last them through the dry season, and thus become more or less succulent. The water is usually stored in *aqueous tissue*, consisting of large colourless living cells, often below the upper epidermis of the leaf, as in Aeschynanthus, Peperomia, &c. More extreme development of the storage-function leads to the true *succulent* plants. The storage may be in the leaf, as in most Crassulaceae, many Liliaceae (*e.g.* Aloe, Haworthia, Gasteria, &c.), Aizoaceae (*e.g.* Mesembryanthemum), Drymoglossum, Agave, Fourcroya, Sansevieria, &c., or in the stem, as in Cactaceae, many Asclepiadaceae (*e.g.* Stapelia, Huernia, Sarcostemma, Ceropegia, &c.), Euphorbia sp., Senecio sp., Sarcocaulon, Salicornia, &c. In the leaf-succulents the leaves are thick and fleshy, are usually closely packed, and provided with thick cuticle, sunk stomata, &c. In the stem-succulents the leaves are reduced to scales or thorns; the stems are fleshy and of various shapes, and are often grooved. Many succulents, especially the Cacti, are able to survive very protracted drought. It is difficult to dry specimens for the herbarium. They do not resist long-continued wet weather easily, but soon decay.

Xerophytes show in general the characters of sun-plants, *e.g.* a very well-developed palisade-tissue, thick leaf, &c. The wood is usually hard, dry, and brittle. Many, especially the desert species, are thorny, *e.g.* Alhagi, Acanthophyllum, Acantholimon, Astragalus, Euphorbia, Cactaceae, &c. The thorns are probably useful as protections against animals, especially in the succulent species.

Bud-protection against extreme heat and excessive transpiration is well marked in most xerophytes. In the succulent forms, *e.g.* Mesembryanthemum, Aloe, Agave, Cactaceae, the bud is usually deeply sunk among the leaves or in a groove or pit in the stem, so that it is almost completely covered. Other protections, of the various kinds already described, occur in other species. The dry-season buds of non-evergreen species show protections like those of winter-buds.

The flowers are often produced in the dry season, or at the beginning of it, or during the drier parts of the wet season, and many have bud-protections, *e.g.* Eucalyptus and other Myrtaceae. The conspicuousness of the flower is often aided by, or entirely due to, the stamens, as in Acacia, Callistemon, &c.; there is not much risk of the pollen being spoiled by rain, and hence the protections found in flowers of wetter climates are not necessary here. Other flowers that freely expose their pollen are Grevillea and most other Proteaceae, &c.

The seeds of many xerophytes are exposed to severe drought before the rains come on, and require good protection. Those of many Proteaceae (*e.g.* Banksia, Xylomelum), of Eucalyptus, Casuarina, &c., are enclosed in hard, woody fruits. Many are enclosed in fruits which only open when wetted (the reverse of the usual behaviour, see p. 107); *e.g.* Anastatica, Mesembryanthemum, Odontospermum. The phenomena of germination are often interesting (p. 29).

There are a great many species which vegetate only during the wet season and die down or drop their leaves in the dry season. Schimper terms such plants *tropophytes*, as being xerophytic at one period, and *hygrophytic*, *i.e.* living with plentiful water-supply, at another. Annual species, which exist only as seeds during the drought, are common. Anastatica is one of the best known. Bulbous plants are abundant in many of the regions mentioned above, *e.g.* in California, South Africa, &c. Other perennials have underground storage in tubers, *e.g.* Bowiea, Testudinaria, &c.; when the tuber, as in the latter genus, projects above the soil it is usually protected by a thick bark. Thick roots occur in other xerophytes. Many shrubs and trees drop their leaves in the dry season and store reserves to start growth when the rains begin. The "Catinga" forests of Brazil consist chiefly of species of this kind; many Bombacaceae, Jatropha, &c., are examples. They are usually well protected by thick bark and have deeply-penetrating roots. It seems probable that the autumnal defoliation of most trees in temperate climates is a similar case; the soil is cold in winter, checking absorption, and perennials must be xerophytic during that season. Evergreens of cold climates, *e.g.* the pines, have xerophytic leaves.

Further details will be found in Part II.; see the orders and genera mentioned above, and Velloziaceae, Cheilanthes, Espeletia, Dasylirion, Lewisia, &c.

Sea-coast and Salt-steppe Plants, or *halophytes*[1], exhibit xerophytic characters, but form so distinct a group that it is convenient to deal with them separately. The presence of salt renders absorption of water by the roots slow, and thus there is less available for transpiration, and at the same time its presence in the assimilating cells checks the process of assimilation and may even stop it altogether or kill the plant if the concentration become too great. A reduction of transpiration is a primary necessity to such plants. There are also many plants that grow on sand-dunes a little way from the sea; here there is less salt but the soil is not retentive of water, and therefore there must be a reduction of transpiration. The group is composed of members of many natural orders; the Chenopodiaceae, Aizoaceae, Plumbaginaceae. The Rhizophoraceae, Frankeniaceae, &c., consist chiefly of halophytes.

The structural characters of halophytes are described below in dealing with the zones of vegetation. They show in general a marked xerophytic structure, with a decided tendency to succulence. Many have fruits or seeds specially adapted to transport by marine currents.

Mesophytes[2]. Under this term Warming classes plants occupying, in regard to dryness of the soil and air in which they live, an intermediate position between hydrophytes and xerophytes. They live chiefly in districts where the rainfall is pretty evenly distributed through the year, *e.g.* in the colder parts of the temperate zones, and in the equatorial regions. They form meadows, evergreen or deciduous woods, coppices, &c. Usually there are many species, and they cover the ground very fully. Evidently the group shades into the xerophytes, including a large part of the tropophytes above mentioned.

[1] Warming, *Halofytstudier* in Kgl. Dansk. Vid. Selsk. Skr. 6, VIII. 1897; *Oekologische Pflanzengeographie* (*cf.* literature there quoted); Schimper, *Die Indomalayische Strandflora*, Jena, 1890.

[2] Warming and Schimper, *op. cit.*

Structurally, mesophytes show few marked features, on account of their intermediate position between the extremes. Their leaf structure is usually well suited to rapid transpiration, though in tropical forests a certain amount of protection against the great midday heat is found. The epidermis is generally thin, the leaves dorsiventral, the stomata numerous. The plants are freely branched and expose as much surface to air and light as possible.

Climbing Plants[1]. We may divide plants according to their habit and mode of growth into another series of forms of vegetation including erect plants, creepers, climbers, and epiphytes. Climbers form a group founded upon a biological peculiarity and include plants of many different families. They occur in most parts of the globe, abounding in tropical forests, where they often grow very large and woody and form a characteristic feature of the vegetation. The climbing plant throws its weight upon an external support, and thus evades the necessity of forming a rigid stem capable of standing by itself. The great bulk of an erect stem consists of fibres, whose function is mechanical. Comparatively few of these are produced in a climbing plant, and its growth in length is correspondingly more rapid, so that it is able to reach the full daylight much sooner than an erect plant. In a dense tropical forest this is a point of great importance to the species, and even in temperate climates many plants owe much of their success to this habit.

Darwin divides these plants into four groups.

I. *Twining Plants* climb by twining round their supports. These must not be very thick nor very smooth, and must stand more or less upright, otherwise the stems are not able to twine. Twiners exhibit many of the characters of etiolated plants (p. 35); they have long thin stems, with nodes far apart, and the growing and elongating part at the tip is very long, and shows very marked nutation in consequence (p. 35). The nutating tip may describe quite a large circle, even several feet in diameter, thus having a better chance of finding a support. Plants of this kind are often supposed to have been evolved in the shade of forests or other

[1] Darwin, *Climbing Plants*; Schenk, *Biologie und Anatomie der Lianen*, Jena, 1892.

vegetation, the etiolation-characters thus produced gradually leading to a twining habit and becoming hereditarily fixed. The actual mechanism of twining is not clearly understood. Nutation alone is not sufficient to account for it. The aid of negative geotropism, which is strongly marked in many twiners, is therefore invoked, but we cannot clearly explain the exact mechanism.

The spiral may be right- or left-handed; the same plant or species usually twines throughout in the same way. The direction may be defined as clockwise, *i.e.* in the direction of the hands of a clock, or counter-clockwise; the terms right and left are used in opposite senses by different writers. The stem usually becomes twisted upon its own axis, but there is no relation between the number of turns of the spiral and the number of twists. The length of the internodes is usually sufficient to ensure the leaves not overlapping each other, and no special forms of phyllotaxis are found.

In the British flora twiners occur in the genera Tamus, Humulus, Aristolochia, Polygonum, Calystegia, Convolvulus, Cuscuta (this genus has sensitive stems, like tendrils), Solanum, Lonicera. Other genera of interest are Lygodium (fern with twining midrib of leaf), Ruscus, Cassytha, many Lardizabalaceae, Menispermaceae, and Malpighiaceae, Wistaria, Phaseolus, many Loasaceae and Combretaceae, Plumbago, Dipladenia, Cynanchum, Ceropegia, Hoya, Ipomœa, Thunbergia, Mikania, &c. Many of these have hooks on the stem, aiding them in clinging to their supports, *e.g.* Humulus, Dipladenia.

II. *Climbers with sensitive organs.* These possess organs which are sensitive to continued contact and which move in response to this stimulus. As in other cases of adaptation, various parts have become adapted to this end. In the majority of these plants the organs are *tendrils*, long thread-like structures with rapid growth and marked nutation. If one side of a tendril come into contact with a support, it grows less rapidly than the other side, and thus the tendril curves towards the support. This brings a new surface into contact and the movement becomes more marked, and so on until the free end of the tendril is all wound round the support. Afterwards the free portion of the tendril twists into a spiral and becomes woody, thus forming a firm but elastic support, and at the same time dragging the stem upwards and thus economising its materials. The direction of the twist reverses at some point in the spiral; this is a mere mechanical result. To twist a piece of wire, fast at both ends, into a spiral, it will be found necessary to reverse the twist at the middle.

Some tendrils, *e.g.* in Vitis sp., have adhesive discs at the end, others, *e.g.* in Cobaea, hooks.

Tendrils, morphologically considered, may be of various nature—stems (usually modified inflorescence-axes), leaves or parts of leaves, or even roots, *e.g.* the aerial roots of Vanilla and perhaps other plants. Modified stipules form the tendrils of Smilax, &c., modified leaves or parts of leaves those of many Leguminosae (*e.g.* Lathyrus, Vicia, &c.), Bignoniaceae (*e.g.* Bignonia) and Cucurbitaceae, Mutisia, Cobaea, Corydalis, &c.; modified stem-structures occur in Vitis, Passiflora, Antigonon, Landolphia, &c. A special form of tendril is the sensitive hook that occurs in so many tropical climbers. Inflorescence-axes, modified in structure to form recurved hooks, project from the stem; when a hook catches a support, it clasps it tightly and becomes lignified, *e.g.* in Artabotrys, Hugonia, Uvaria, Ourouparia, Unona, Ancistrocladus, Landolphia, Strychnos, Uncaria, &c. Sometimes they are long, thin and flat, and are rolled up like watch-springs, as in some Sapindaceae (Paullinia, &c.), Gouania, Bauhinia, &c.

Many plants climb by aid of sensitive leaves. In Gloriosa, Littonia, &c., the tip of the leaf is sensitive, acting like a tendril. The petiole is often sensitive to contact, usually clasping once round its support, and then frequently becoming woody, *e.g.* in Tropaeolum, Clematis, Hablitzia, Maurandia, Rhodochiton, &c. *Cf.* also the leaf-climbers, Fumaria, Adlumia, and Nepenthes (see Part II.).

Other plants climb by aid of sensitive lateral branches, which bear ordinary leaves, *e.g.* Securidaca, Hippocratea, Uvaria, Salacia, Machaerium, &c. Sometimes the branches are leafless and tendril-like, but they are always capable of producing leaves.

III. *Hook-climbers* sprawl over other vegetation, and have hooks, usually recurved, which aid in their support. The only British hook-climbers are Galium and Rubus, both of them with small hooks arising as mere emergences

(p. 114); in the tropics many hook-climbers grow to a great size and have stem- or leaf-structures modified into hooks, *e.g.* Calamus, Desmoncus, Caesalpinia. *Cf.* also Rosa, Pereskia, Capparis, Lycium, &c. These hooks are not sensitive to contact like those described in the preceding section.

IV. *Root-climbers* climb by aid of special adventitious roots upon the stems. These are not usually sensitive to gravity but show a marked negative heliotropism, which causes them to follow out all the crannies and irregularities of the surface upon which they creep, and thus to firmly attach themselves to it. Instances are ivy (Hedera), many Araceae, Hoya, Tecoma, Norantea, Ficus sp., Piper sp., and many ferns. The aerial roots of Philodendron sp. twine as they descend. Ivy and others have dimorphic shoots (*cf.* Salacia, &c.).

Anatomically, climbing plants present many features of interest. The stem is very thin compared to its length, but grows slowly in thickness to supply the new leaves with water. The growth is commonly 'abnormal' and results in many cases of tropical climbers (*lianes*) in stems of the most remarkable shapes—flat, twisted, corrugated, &c.—which may be seen in most museums.

Creeping plants, in which may be included those with horizontal rhizomes (p. 153), are like climbers in throwing the weight upon outside supports, and grow but little in thickness. They are common in meadows, and in the undergrowth of woods.

Epiphytes[1] cling to other plants for support, but are not parasitic upon them, and are not usually attached to the soil. In the temperate zones they are rare—except among Algae, Mosses and Liverworts—but in the wetter forest regions of the tropics they abound, perched upon the branches and even leaves of other trees and plants, forming a marked feature in the vegetation. Being usually small herbs they thus obtain favourable situations without the expenditure on stems needed by erect plants and even by climbers, but on the other hand the obtaining of food

[1] Schimper, *Die Epiphytische Vegetation Amerikas*, Jena, 1888; Goebel, *Pflanzenbiologische Schilderungen*; Willis and Burkill, *Flora of Pollard Willows*, Proc. Camb. Phil. Soc. 1893.

(except carbon) becomes more difficult. Most of them are excellently suited in structure and physiology to their mode of life, and yet possess few or in some cases no true adaptations to it. The group is made up of a number of genera which happen to possess in common a number of characters—adaptations to various ends—which enable their possessors to become epiphytic. The ferns, Bromeliaceae, Orchidaceae and Araceae are largely represented in the group; important genera of epiphytes, not belonging to these families, are Piper, Clusia, Phyllocactus, Rhipsalis, Columnea, Dischidia, Aeschynanthus, Hydnophytum, Myrmecodia, &c.

In the first place, no plant can become epiphytic unless it has an excellent seed-dispersal mechanism. Wind and birds are the only agents capable of regularly carrying the seeds to sufficient heights. All epiphytes possess either wind or bird mechanisms. Interesting observations may be made on this part of the subject by studying the flora of pollard trees in Europe; many species occur in the bowls of humus at the tops of willows, &c., almost all wind- and animal-dispersed; about 15 % of the species (3 % of the individuals) have mechanisms incapable of transporting their seeds to the requisite height, and of these many are carried up, more or less accidentally, by birds in nest-making.

In the second place, a species to become a successful epiphyte must be able to fasten itself to its support, and at once after germination. Just as in Europe plants with good dispersal-methods may become epiphytes in willows, where there is plenty of food and no difficulty in anchorage, so in the tropics many become accidental epiphytes in the leaf-sheaths of Palms, or in the pitchers of Bromeliaceae, and so on. True epiphytes however are able to cling to almost any support at any angle, usually by means of clasping roots of the kind found in root-climbers. Such roots are always adventitious, developed from the stem; thus we can perhaps understand why Monocotyledons form so large a proportion of the epiphytic flora. Tap-rooting plants, as so many of the Dicotyledons are, would not be able to cling to their supports in time to prevent falling off. One group of epiphytes, the Araceae (*q.v.*), seems to have been evolved from plants which originally climbed with clasping roots.

In the third place, epiphytes are placed in conditions where the water-supply is small and precarious and easily runs away. No plants then can be regular epiphytes unless they possess well-marked xerophytic characters, including as a rule the capacity for water-storage. The Orchidaceae collect water by their aerial roots and store it in tubers or fleshy leaves; Bromeliaceae have fleshy leaves and water-collecting pitchers; ferns have fleshy stems and also gather much humus which retains water well; 'aqueous tissue' in which water is stored occurs in the leaves of Aeschynanthus, Peperomia, &c.; other arrangements occur in other species. Peculiar semi-epiphytism occurs in many Araceae (*q.v.*) which have long nutritive roots descending to the soil, and in species of Clusia and Ficus.

Most epiphytes obtain the mineral substances required for nutrition from decaying organic matter (*humus*), and many have interesting arrangements for its collection. In most forms a certain amount of dead leaves and other *débris* collect at the base of the plant; in many ferns the leaves make niches against the support, *e.g.* in Polypodium sp. and Platycerium, or form nests, as in *Asplenium nidus*; in Dischidia the pitchers collect humus, and also in Bromeliaceae. See Part II.

Moisture seems everywhere an important factor in regulating the distribution of epiphytes. In deep ravines in Europe the trees may be seen loaded with epiphytic ferns, &c. Plants living on the soil in a tropical forest may similarly become epiphytic to this extent if they possess the necessary methods for seed-dispersal and anchorage of the seedlings. They may then gradually work higher up the trees, and thus get nearer to the light as they develope xerophytic characters to enable them to stand the increased transpiration, and so on. In actual fact we find epiphytes with very pronounced xerophily on the very tops of trees, others with less marked characters lower down. On the savannahs of America, where the climate is drier, the species from the tops of the forest trees occur as epiphytes, but no others. These well-marked epiphytic species also occur as alpine forms in neighbouring mountains, but not in the intermediate zone; they are equally well adapted for this form of life. So also they become shore-plants.

For further details see Part II., especially Polypodium, Platycerium, Bromeliaceae, Tillandsia, Araceae, Orchidaceae, Vanilla, Oncidium, Bulbophyllum, Scuticaria, Phalaenopsis, Clusia, Ficus, Marcgravia, Dischidia, Rhododendron, Myrmecodia.

Parasites[1]. We may again divide plants according to their mode of nutrition into independent plants, which take in all their food as simple inorganic compounds, parasites, saprophytes, and insectivorous plants. Parasites draw the whole or part of their food-materials from other plants (their *hosts*) by means of special organs termed *suckers* or *haustoria*. They are very numerous among the Fungi, and there are many parasitic seed-plants, certain orders being entirely composed of them, *e.g.* Loranthaceae, Rafflesiaceae, &c. In most of these cases the suckers are modified roots, developed from the parasite at points of close contact with the host. The sucker penetrates the tissues of the host plant and grows into organic union with them; if the host grow in thickness, the suckers grow in length to keep pace with it. Some parasites are confined to one species of host, others are more general in their attacks.

Parasites are classed as *total* or *partial*, according to whether they take all or some of their nourishment from the host. In the latter case they appear only to take raw materials—the water and other substances absorbed by the roots—and therefore require green tissue of their own. In the former case chlorophyll is rendered useless, and they possess none; their leaves are reduced to a more or less rudimentary condition or even the whole shoot, as in Rafflesiaceae, whose vegetative body is reduced to a mycelium like that of a fungus. The inflorescence of parasites, on the other hand, is comparatively little degraded in structure.

The simplest form of partial parasitism occurs in the Rhinanthus group of Scrophulariaceae (*q.v.*), and in Thesium and some Santalaceae; all are parasitic by their roots upon the roots of grasses, &c. Viscum and other Loranthaceae, Myzodendraceae, &c., are parasitic upon the stems of their hosts, and may be mistaken for epiphytes.

[1] Schimper, *op. cit.*; Hemsley in Linn. Soc. Journ. XXXI.

Total parasitism is well shown in Cuscuta and Cassytha, with their twining stems and absence of chlorophyll and of leaves; these are both parasitic upon stems, while Orobanche, Lathraea, &c., are total parasites upon roots. A further step in the degradation of the vegetative system leads to the very remarkable orders Balanophoraceae, Hydnoraceae, and Rafflesiaceae, above mentioned.

Saprophytes[1] are plants which grow upon decaying organic matter and absorb the products of decay. Such are most of the Fungi, perhaps a few Mosses, &c., and a few flowering plants, *e.g.* the Orchidaceae Neottia, Epipogon, and Corallorhiza, the Triuridaceae, the Burmanniaceae, and Bartonia, Monotropa, &c. The prothallus of Ophioglossum is also saprophytic.

It is probable that many plants are more or less saprophytes in a sense. The complete saprophytes above mentioned have no green tissue at all, for they take in their carbon from the soil in the form of complex organic compounds. These bodies possess potential energy, and therefore the absorption of light-energy becomes needless. Chlorophyll is thus rendered useless and is no longer produced, while at the same time, as there is no absorption of carbon dioxide from the air and the elaboration of new protoplasm may go on anywhere in the plant, the leaves, as in total parasites, are rendered useless also (being needed neither for assimilation nor transpiration), and are reduced to small scales. Many of these plants, *e.g.* Monotropa, possess a mycorhiza (p. 39), and it is very likely that all plants which have this *symbiosis* (or living together for mutual benefit) with the fungus are to some extent saprophytic, in that they take up more or less of the complex products of decay from the soil.

Insectivorous Plants[2] obtain more or less nourishment from the dead bodies of small animals captured by means of special apparatus. There are about 400 species of these plants, belonging to 16 genera, in the orders Droseraceae (Drosera, Drosophyllum, Dionaea, Aldrovanda, &c.), Sarraceniaceae (Sarracenia, Heliamphora, Darling-

[1] Schimper, *op. cit.*; Johow in Prings. Jahrb. XVI, XX.
[2] Darwin, *Insectivorous Plants*; Goebel, *Pflanzenbiologische Schilderungen.*

tonia), Nepenthaceae (Nepenthes), Cephalotaceae (Cephalotus), and Lentibulariaceae (Pinguicula, Utricularia, Genlisea, &c.). Of these Drosera, Pinguicula and Utricularia occur in Britain.

They may be divided in groups according to their mode of catching their prey. Drosophyllum, Byblis, Roridula, Pinguicula, Drosera have glandular hairs secreting a sticky fluid to which insects, mistaking it for honey, adhere. In the two last named movements of the leaf or tentacles occur when stimulated by the presence of proteid bodies. All these secrete a digestive fluid which dissolves the greater part of the animal substance. Sensitive motile organs, which close upon the prey, occur in Dionaea and Aldrovanda, in both of which part of the leaf is modified to form the trap. Digestive fluids are secreted in these also. A third group is the pitcher plants—Nepenthes, Cephalotus and the Sarraceniaceae—in which the leaves or portions of them form upright pitchers with hoods over their mouths. The upper part of the pitcher secretes honey, which attracts flies, and these gradually get further into the pitcher; the inner surface is slippery and they find it more easy to go downwards than to return and are ultimately drowned in the water at the bottom. It is doubtful whether the plant in these cases secretes a digestive ferment, or whether it merely absorbs the products of decay and is thus saprophytic; the water in the pitcher swarms with bacteria, which rapidly decompose organic matter. Lastly there is the group of 'eel-trap' plants—Utricularia, Biovularia, Polypompholyx and Genlisea—in which animals are caught in traps of various shapes, from which there is no escape. They decay and the plant absorbs the products. *Cf.* details in Pt. II.

Zones of Vegetation, Plant-Associations, &c.[1] The local distribution and the periodicity of the climatic factors—light, heat, and moisture—are accompanied by a corresponding division of the earth's surface into *zones of*

[1] Cf. Map of Floral Regions (frontispiece). Drude, *Handbuch der Pflanzengeographie*; Warming, *Oekologische Pflanzengeographie*; Schimper, *Pflanzengeographie*; Miall, *A Yorkshire Moor*, Nature, Aug. 1898; Smith, *Plant Associations*, Nat. Science, 1898; and *cf.* subsequent footnotes.

vegetation, *i.e.* zones occupied by similar types of vegetation, with the same periods of growth and with similar general adaptation to their environment. These divisions are purely climatic-ecological, and in dealing with them the systematic relationships of the plants are neglected.

In a similar way the zones themselves may be divided upon an ecological basis into smaller areas, possessing similar soil, climate, and other conditions, and occupied by the same kind of plants, grouped in the same general way. Such grouping of plants as make up or occupy an alpine meadow, a beechwood, a salt marsh, a cultivated meadow, a heath, a peatmoor, forms the unit. It is sometimes called a *formation*, but this word has been used in so many senses that it is better avoided, and the term *plant-association* or *plant-society* used. Given a certain combination of climatic and other ecological factors, soil, &c. a given area will be occupied by a definite association of certain plants, which will bear a fairly definite numerical relationship to one another. Some species will usually be very abundant, or *dominant*, as for instance the heather, *Calluna vulgaris*, on most dry moors or heaths in Scotland; others will be *sub-dominant*, as the Ericas in the same association, while others again will be comparatively rare, though usually occurring in similar proportions in similar areas. If the conditions of life change, as in passing from a level to a slope, from a slope to a rocky precipice, from well drained to wet land, or from one soil to another, the grouping of the plants changes also, and the association is modified, or passes over into another association more or less rapidly according to the rate of change of the conditions. Or, without change of locality, the conditions may be changed by the introduction of a new species of plant from abroad, which may prove able to establish itself in the association and thus modify the proportions and interrelationships of the other species. Or again, the invasion of grazing animals may keep down some species, and encourage others.

Many of the species in an association will compete strenuously with one another, as they will be ecologically similar, using the same food-stuffs in similar proportions, or relying on the same insects for pollination. Others will be dependent species, *e.g.* parasites upon their hosts, saprophytes or plants with mycorhiza on the humus formed by particular species, and so on.

While in general a given species will be found only or chiefly in a certain association, this is not always the case. One ecological combination of factors may replace another; thus many alpine plants also occur in associations confined to the seashore, others again as epiphytes in the lowland forests.

The study of plant associations and their mutual competition, and the effects produced by modifications of conditions is already yielding much information of value in geographical distribution, and throws much light on the study of evolution, morphology, &c.

To describe the many associations occurring in the different zones would far exceed the limits of this work; but an indication is given of some of the more important features of the vegetation of each zone.

Drude enumerates six zones of vegetation (see Map III. of his Atlas), as follows:

I. Northern glacial zone[1]. This consists of the arctic region (including the Tundras), and is limited on the south by the northern limit of trees (*i.e.* the limit beyond which they do not naturally occur). A corresponding region, counted as part of this zone, occurs above 15,000 feet in Thibet, and in other northern mountain regions at correspondingly lower elevations; *e.g.* in Britain the limit of trees rarely lies above 2000 feet. The mountain zone above the tree-limit is termed the *alpine* zone, and its characteristic plants are termed *alpine plants.* The general habit and structural features of alpine plants are much the same all over the world and resemble those of arctic plants.

In the arctic regions the conditions of life are peculiar; the period during which growth can take place is very short (1—4 months); the average temperature is low; the light is bright and long-continued, and the sun describes an almost complete circle every day, so that the light falls upon the plants from every side in turn at a comparatively low angle;

[1] Schimper, Warming, *op. cit.*; Jungner, Wiesner, etc. cited on p. 143; Jaccard, *Gesetze der Pflanzenvertheilung in der alpine Region*, Flora, 90, p. 349; Müller, *Alpenblumen*, Leipzig, 1881; Willis and Burkill in Trans. Bot. Soc. Edinb. LXVI, 1901, and Ann. of Bot. XVII, 1903.

the soil is thin, and liable to be very much heated at the surface whilst it remains very cold at a little depth (thus hindering absorption by the roots); insects are few and far between, and belong chiefly to the lower classes, especially the Diptera. It is evident therefore that xerophytic structure is a necessity, and in fact it is very marked in the arctic flora. The long-continued light retards growth and the plants show a dwarfed and tufted habit, as may be seen in the common genera Diapensia, Draba, Loiseleuria, Vaccinium, Saxifraga, &c. They also exhibit many of the xerophytic characters described above—reduced surface, closely-packed leaves, inrolled leaves, fleshiness, thick cuticle, hairiness, sunk stomata, and so on. The flowers show, as compared with the same species in warmer regions, an increased tendency to autogamy, and there is a marked increase of vegetative propagation, especially in species that are not capable of autogamy. Eutropous flowers are few, and often have shorter tubes, which enable hemitropous insects to reach the honey (p. 94). The genera above mentioned grow chiefly in the more rocky or dry places: the wetter moors are occupied by such plants as Juncus, Scirpus, Carex, and many grasses. Most of these are characterised by erect centric stems or leaves, so that the green tissue is almost or quite symmetrically arranged, facing to every quarter of the compass. Jungner regards this as an adaptation to the peculiar 'circumpolar' light that falls on every side of the plant in turn. Annual plants are comparatively few in number, and few woody species occur; the arctic species of Betula, Salix, &c. are low-growing, almost herbaceous plants.

The resemblance of the flora of the Grampians or the mountains of Norway or Germany to that of the arctic regions is at once evident, most of the species being the same. At low levels the flora is like that of the lowlands from which the mountains rise, but marked by the absence of many species and the presence of others (subalpine), *e.g.* Meum, *Viola lutea*, &c. In ascending, the lowland species gradually disappear; very few of them reach above 1000 feet in the Grampians, and these mostly do not pass above 3000 feet, while other species take their place and in turn disappear at still higher levels. The upper limit of trees (Coniferae and Betula) lies at about 2000 feet in the

Grampians. The more strictly alpine plants do not descend into the plains, though they often occur as sea-coast plants, or (in the tropics) as epiphytes (see p. 175).

The conditions of life in this region resemble those of the arctic regions sufficiently nearly to enable the same species to live in both. The air is moister in the alpine region, especially in the lower part, but the low barometric pressure favours transpiration; the light is more intense than at low levels, and on high plateaux is more or less circumpolar; the vegetative season is short; the soil is liable to extremes of cold or heat; there is much wind; the frequent presence of clouds diffuses the light and saturates the air at certain times.

The composition of the flora depends upon the soil and other conditions, though the plants themselves are all more or less xerophytic. Upon the high-level plateaux where the soil is cold and wet the dampest parts are occupied chiefly by peat-forming mosses, but on the firmer parts of the peaty soil occur species of Juncus, Eriophorum, Eleocharis, Carex, Scirpus, Festuca, Nardus, &c. All these show a more or less centric structure. Circumpolar light is very marked in such localities, and some authors regard the form of these plants as a direct result of its action; whether this be so or not they are well suited to make the best use of it. Most of them contain large air-spaces, intercellular or enclosed by the leaves; these are sometimes regarded as protections against cold (*cf.* p. 161), the air they enclose being warmer than the outside air. On the summits of the ridges, where the soil is drier and more rocky, the vegetation consists largely of such plants as Calluna, Loiseleuria, Vaccinium, Arctostaphylos, Gnaphalium, Empetrum, Lycopodium, &c. All are pronounced xerophytes, usually evergreen, and thus the winter's cold becomes perhaps the most important factor in their life. Most of them have more or less inrolled leaves, which perhaps, as we have seen, act as a protection against the cold; at the same time these leaves have palisade tissue almost all round and stand more or less erect, so that they are well suited to the circumpolar light. Such leaves are termed by Jungner *cold-leaves*.

There is no perpetual snow in the Grampians, but heaps of snow lie until July or August in hollows on the mountains, and the plants growing near them are thus subjected in a more marked degree than elsewhere to a cold wet soil and atmosphere. In such places are found chiefly *Salix herbacea* and *reticulata*, *Oxyria digyna*, *Saxifraga stellaris*, &c. Most of these have thin round deciduous leaves, with serrated edges. These are termed *alpine snow-leaves* by Jungner; they are well able to survive burial in snow.

The open slopes, where the ground is not very wet, are chiefly covered by *Alchemilla alpina*, Erica, Calluna and Vaccinium, with patches of grasses, *Potentilla Tormentilla*, Polygala, Trientalis, and other flowers. The wet places by the sides of streams are occupied by mosses, liverworts, and a few flowering plants, *e.g.* Saxifraga sp. (especially *S. stellaris* and *aizoides*), Chrysosplenium, Caltha, Geranium, *Geum rivale*, &c. Many of these are lowland species which in sheltered glens ascend to great heights and mingle with the descending alpine forms.

Upon precipitous rocks a different flora appears. Here the soil is even more shallow than on the gentler slopes, and only those species with good tap-roots, or with rhizomes, runners, or tufted growth are usually able to live in such situations. The xerophytism is very marked, for the water supply is very limited. Here occur *Thalictrum alpinum*, *Silene acaulis*, *Arenaria Cherleria*, *Cerastium alpinum* (hairy), *Sedum rhodiola* (fleshy), *Saxifraga oppositifolia* (fleshy), Saussurea (hairy), Hieracium sp., Juniperus, and others. In wet places other forms occur, and many lowland species also, such as *Alchemilla vulgaris*, *Lychnis dioica*, Oxalis, *Lotus corniculatus*, &c.

All these alpine forms show more or less marked xerophytic characters—hairiness, fleshiness, reduction of surface, tufted and compacted growth, &c. On the Alps and on other mountains similar conditions of life occur at similar distances below the snow line, and the flora, though differing in composition, exhibits similar biological features. Details must be sought elsewhere.

Many plants of the shore-flora occur at high levels in the Grampians and other mountains, *e.g.* Armeria, Plantago sp., Cochlearia sp. (see below).

In the mountains of Britain and Norway insects are scarce at high levels, and are chiefly humble-bees and flies.

Those flowers which like Vaccinium, Erica, Calluna, &c., or Alchemilla, Saxifraga, Potentilla, &c., are adapted to one or other of these groups, form the chief features of the entomophilous flora of these regions. Anemophilous flowers (*e.g.* Thalictrum, Cyperaceae, Juncaceae, Gramineae) are very abundant. Vegetative reproduction is common (especially interesting cases are *Polygonum viviparum*, *Saxifraga cernua*, &c.) and in general the floral features and mechanisms resemble those of the arctic regions. In the Alps it is different. At high levels butterflies and moths abound, and the flowers adapted to them figure largely in the flora, *e.g.* Gentiana, Viola, Silene, Dianthus, Daphne, Primula, &c. Insect visitors are present in sufficient numbers to enable most flowers to do without much self-fertilisation or vegetative reproduction. They have apparently determined the evolution of the endemic species into butterfly-flowers, &c., for there are many cases where the alpine species of a genus belongs to class F, the lowland to classes with shorter tubes, *e.g.* H. The flowers of alpine plants show, in general, brighter colours than those of low levels; this is apparently a direct effect of the brighter light.

II. Northern zone of cold winters[1]. This extends from the northern limit of trees to the latitude in which evergreen branched trees and shrubs begin to predominate, and in which the country is parched in summer. It reaches in Europe to the south of France and to Greece, and in Asia to about 50° N.; in North America it includes most of Canada, the western United States as far south as Utah, and the New England States. Corresponding areas occur in the various mountain-ranges. The period of vegetation lasts during 3 to 7 months, with its maximum in July; the

[1] Schimper, Warming, etc., *op. cit.*; Flahault, *Essai d'une carte botanique et forestière de la France*, Ann. de Géog., 1897; Graebner, *Studien über die norddeutsche Heide*, Engl. Jahrb. XX, 1895 (and *cf.* recent volumes of this journal); Sernander, *Den Skandinaviska vegetationens spridningsbiologi*, Upsala, 1901 (*cf.* Bot. Centr. 88, 380); Engler, *Die pflanzengeographische Gliederung Nordamerikas*, Notizbl. k. Bot. Gtns., Berlin, 1902; Pound and Clement, *Vegetative Regions of the Prairie Province*, Bot. Gaz. XXV, 1898, p. 381, and many papers in same journal in recent years by these authors, Cowles, Livingston, etc.; Macmillan, *Minnesota Plant Life*, St Paul, 1899; and *cf.* above, Halophytes, Alpine Plants, etc.

summers are not so dry as to parch the vegetation. The plant-associations are very numerous, and may be grouped into classes, *e.g.* forests, heaths, meadows, &c. They are largely mesophytic.

The forests occupy vast areas in this zone, though much reduced by man's operations in modern times. The chief elements are the Conifers (Abies, Pinus, Larix, &c.), mostly with evergreen xerophytic leaves (Larix, the most northern form, is deciduous), the catkinate families (Fagaceae, Betulaceae), Acer, Tilia, Fraxinus, &c. Many of these are of *social* habit, and form homogeneous forests, of one species only, in certain regions, *e.g.* pine, birch, beech, &c. All but the Conifers are deciduous. The undergrowth of such forests consists of young trees of the same species, and of a few shrubs and small woody climbers (*e.g.* Lonicera); on the soil grow ferns (never arborescent), grasses, and various herbs. The latter are characterised by their early development in spring, before the trees are in full leaf, so that they obtain the maximum of available light. Familiar instances in Europe are the primrose, violet, hyacinth (Scilla), Adoxa, Anemone, &c. Later in the year the saprophytic plants (Monotropa, Neottia, &c.) appear. Epiphytic phanerogams do not occur, but in very moist places ferns are often epiphytic, and the tree-bark is usually covered with algae, lichens, liverworts, &c. Other associations are the copses of small trees and larger shrubs, such as willow (Salix), hazel (Corylus), hawthorn (Crataegus), &c.

Another class of associations is that of the heaths, which cover immense areas in some parts of this zone. The chief plants are the Ericaceae, Calluna, Erica, and Vaccinium; others are gorse (Ulex), Ledum, Salix sp., &c.; among these occur grasses and other herbaceous plants. Most of these plants are decidedly xerophytic. Hydrophytes, on the other hand (see above), are also common in this zone, lakes, rivers, and marshes abounding.

This zone also contains numerous associations, in which the Gramineae (or in wet ground the Cyperaceae) dominate, forming a turf; amongst them grow numerous herbaceous plants, *e.g.* many Compositae, Campanulaceae, Labiatae, Scrophulariaceae, Umbelliferae, Onagraceae, Leguminosae, Geraniaceae, Cruciferae, Carophyllaceae, Ranunculaceae, Polygonaceae, Liliaceae, Juncaceae, &c. Examples are the prairies of the northern United States and Canada, the northern steppes of Russia and Siberia, meadows, moors, pastures, etc. The plants occupying them are in general mesophytic, but the grass-lands are usually drier than the forest-lands.

The coasts exhibit many interesting plant-associations, according to the nature of the soil, whether rock, sand, or mud. The following remarks refer specially to Britain and Western Europe. Upon rocks we find such plants as *Crithmum maritimum*, *Silene maritima*, &c. The flora of a sandy coast varies according to the distance from the sea. On the sandy shore itself, where the soil is saturated with salt water at a small depth, but is liable to become very hot and dry at the surface, occur such plants as *Cakile maritima*, *Salsola kali*, species of Atriplex, *Arenaria peploides*, *Calystegia soldanella*, Crambe, Mertensia, *Glaucium flavum*, *Eryngium maritimum*, &c.; these are mostly annuals, or perennials with creeping stems, or long tap-roots by which they are firmly anchored to the soil. All are more or less fleshy, and show other xerophytic characters (sunk stomata, thick cuticle, wax, &c.) as well. A little further back from the sea the region of sand-dunes begins; those close to the shore are always shifting under the action of the wind, and only those plants occur upon them that besides being xerophytes are able to come up again if buried by the sand (the formation of dunes is chiefly due to the growth of these plants) and which possess good anchorage. Such are the grasses *Ammophila arundinacea* and *Elymus arenaria*, with long rhizomes and often with leaves which roll up in dry air. *Carex arenaria*, *Hippophae rhamnoides* and other plants may also occur here. The growth of these plants gradually binds the dunes together, and further inland they form a sufficiently stable soil for the growth of such plants as *Carex arenaria*, species of Festuca, Ononis, *Lotus corniculatus*, *Galium verum*, *Sedum acre*, *Antennaria dioica*, Thymus, and frequently Erica and Calluna. These also show more or less marked xerophily; the shore forms of Lotus and other inland species are fleshy, and a few other succulents occur, but most of these plants reduce transpiration in other ways. Where the shore is muddy, as in estuaries, a somewhat different flora appears. Farthest out occur masses of Zostera, then *Salicornia herbacea*; both are entirely submerged at high water. Further inland, out of reach of most tides, where the ground is firmer, occur *Glyceria maritima*, *Triglochin maritimum*, *Plantago maritima*, *Suaeda maritima*, Glaux, Statice, Cochlearia, *Spergularia marina*, *Aster tripolium*, &c. Higher up still many of these disappear, their places being taken by Armeria, Festuca, Erythrea, Juncus sp., &c.

Many shore plants in Europe are also found on mountains, a fact easily understood after a comparison of the general conditions of life. Thus in Britain, Armeria, *Plantago maritima*, *Silene maritima*, *Cochlearia maritima*, &c., occur on the mountains at high levels as well as at the coast, but are rare or unknown in the intermediate districts, and in the same way, on the west coast of Scotland some alpine forms, *e.g.* *Saxifraga oppositifolia*, occur at the sea-side.

In the more southern parts of this zone rain is rare in summer, and the transition to the following zone is gradual.

III. Northern zone of hot summers[1]**.** This comprises the subtropical regions lying between zones II. and IV., *i.e.* the basin of the Mediterranean (including Spain and Italy), Asia south of zone II. (excepting India, Indo-China, the Malay Archipelago, and the S.E. coast of Arabia), North Africa, the Sahara, and the rest of the United States and Mexico. The summer temperatures are very high, higher than in the tropics; at night it is often cold. There is no real winter, but at most a slight interruption of vegetation in January. The rainfall varies considerably, and whilst the zone includes the driest parts of the world, it also contains, in Florida, parts of Mexico, South Japan, &c. comparatively wet regions, characterised by dense forests not unlike those of the wet tropics, but less rich in climbers and epiphytes, though in *Tillandsia usneoides* the forests of the southern United States possess probably the most dominant and striking of all epiphytes. In the Mediterranean and Californian regions the rainy season is in the winter, and there is less development of forest.

[1] Schimper, etc., *op. cit.*; *cf.* Xerophytes, etc., above; Berger in Bot. Gaz. XXXV, 1903, p. 350 (Macchie); Burtt Davy in Bull. Bureau Plant Ind. U.S. Dept. Agr., Washington, 1902 (California).

The vegetation of this zone is chiefly xerophytic. Coniferae with needle leaves appear in large numbers in the forests; most of the trees and shrubs are evergreen with branched stems, but there are a number of deciduous forms which are leafless in the dry season. The habit of many of the trees is like that of the Mediterranean stone pine (*Pinus pinea*), which forms a kind of umbrella with almost flat top. Epiphytic ferns occur in the wetter regions.

Copse-associations are common, *e.g.* the 'maquis' or 'macchie' of the Mediterranean coasts, which are composed of many shrubby forms, especially Leguminosae, Cistaceae, *Spartium junceum*, *Myrtus communis*, *Erica arborea*, *Pistacia lentiscus*, *Quercus Ilex*, *Arbutus Unedo*, &c., among which in the rainy weather great numbers of herbaceous forms, including many annuals, are to be found. Another is the 'chaparral' of California and the south-west United States, the chief shrubs in which are *Adenostoma fasciculatum* (chamise), Arctostaphylos sp. (manzanita), *Quercus dumosa*, and others, among which grows a scanty herbage of grasses, &c. A third association of this sort is the Larrea shrub of Mexico, which is still more xerophytic. Others of marked xerophytic type are the Yuccas of Texas, &c., and the larger Cacti of the Arizona deserts.

Large areas are occupied by grass-associations (steppes and prairies), *e.g.* on the eastern side of the Rocky Mts., where Bouteloua and other grasses predominate. These regions are usually much parched in summer. They pass over into drier desert regions, *e.g.* the cactus regions of Arizona and New Mexico. There are also many salt steppes and deserts occupied by halophytes, *e.g.* the genera Haloxylon, Halimondendron, Anabasis, &c., in Asia, and the sage-brush of the western United States (*Artemisia tridentata* and other species).

The coast flora is often shrubby, *e.g.* on the flatter shores of the Mediterranean. The shrubs are generally low growing and much branched, with xerophytic characters.

An outlying flora, similar to that of the wetter parts of this zone in habit, ecology, and other characters, occurs in the higher regions of many tropical mountains, *e.g.* in the Himalayan foot-hills, and in Ceylon and Java.

IV. Tropical Zone[1]. This includes most of the land between the tropics, wherever the rainfall is sufficient to prevent the formation of deserts. It passes gradually into the desert regions of the preceding and the succeeding zones. There is no interruption of vegetation by cold, but in most of the continental parts, excepting the extreme north of Australia, south of India, western equatorial Africa, and the Amazon valley, there is a dry season of at least three months in summer which necessitates a xerophytic character in the vegetation. Part of these drier regions is covered with forest; often many of the trees have deciduous leaves, *e.g.* in the 'Catinga' forests of Brazil. Lianes are less common than in the wet regions described below, epiphytes are few and of the most xerophytic kinds. Cacti, Euphorbias and other xerophytes are common in many parts, and with a few Acacias, &c., may represent the copse vegetation of this zone. Large open areas occur, covered with grasses (Chlorideae, Festuceae, &c.), among which many flowering herbs and undershrubs often occur. In most places these areas are interrupted by patches of copse or forest, and are then termed *savannahs* (America) or *park-lands*.

In the more strictly equatorial regions, *i.e.* in western equatorial Africa, the extreme south of India, the Amazon valley, the extreme north of Australia, and in the islands, *e.g.* southern Ceylon, the Malay Archipelago, &c., there is rain at almost all periods of the year, and especially at the two seasons when the sun has just passed overhead. Here, tropical vegetation is seen in its highest development. The air is constantly warm and moist, the range of temperature is small, there are no extremes of dryness, and everything favours rapid and luxuriant growth.

The bulk of the lowland area is (or was formerly) covered

[1] Schimper, Warming, &c., *op. cit.*; Darwin, *Naturalist's Voyage*; Wallace, *Malay Archipelago*, *Island Life*, *Tropical Nature*, *Naturalist on the Amazon*; Rodway, *In the Guiana Forest*; Kurz, *Report on the Forest and other Vegetation of Pegu*, Calcutta, 1876; Haberlandt, *Eine Botanische Tropenreise*; Pearson, *Botany of the Ceylon Patanas*, Journ. Linn. Soc. XXXIV, 1899, p. 300; Willis and Gardiner in Ann. Perad. I. 1901 (shore plants); Keeble in Ann. of Bot. 1895 (hanging foliage); Stahl in Ann. Buitenz. 1893 (leaf form); Potter in Journ. Linn. Soc., 1888 (bud protection); and *cf.* Climbers, Epiphytes, Halophytes, &c., above.

with mesophytic forest. The trees composing the forests are of many species, and are very rarely of social habit; they are mostly evergreen and have either simple or branched stems. The simple-stemmed evergreens are characteristic of these regions; they are chiefly Monocotyledons, *e.g.* Palms, Pandanaceae, Musaceae, Bamboos, &c. The trees mostly have straight trunks reaching to a height of 50—150 feet or more and bearing their leaves and branches (if any) at the top, where they are exposed to the full sunlight. Buttress-roots are very often found at the base of the trunk. The leaves are mostly more or less leathery with thick cuticle (to this is due the characteristic sharp rattle of the rain-drops in a tropical forest, and the brightness of the light reflected from the leaves); they are often corrugated (*e.g.* in Palms) or turned partly edgewise, or they stand with an upward slope, or (as in some Leguminosae) move upwards as the light becomes more intense, so that they obtain some protection against the radiation. The young leaves in some plants are produced at all periods of the year, in others periodically (often this periodicity has no direct relation to that of the climate); they have usually good arrangements for their protection in the bud, and are very often red in colour. Those trees which have not glossy leaves have usually rain-leaves with drip-tips. The flowers and fruits are very often borne on the older branches or even on the main trunk; the reason for this is not known. Almost nothing is known of the relations of flowers and insects in the tropics. Many flowers are adapted to sun- or humming-birds.

Below the larger trees are the shade-loving trees with thinner leaves, whose crowns reach a height of about 30—50 feet, and below these again occur large herbs and under-shrubs, whilst on the ground are mosses, Selaginellas, saprophytes, &c. Besides these, two forms of vegetation especially characterise the wet tropical forest—lianes and epiphytes, both of which occur in profusion in every available space, so that the forest as a whole forms an inextricable tangle of the most varied vegetation. Parasites, myrmecophilous plants, and other interesting forms are often found.

Grassy openings, except where produced by cultivation, are rare in the wettest regions.

Of the various associations which grow upon tropical coasts the chief is the *mangrove*, found covering the muddy swamps at the mouths of rivers and elsewhere, over which the tide flows daily, leaving the mud bare at low water. The plants found here present a great similarity in habit and other features, though belonging to different families; the association appears to be a very old one, and most of its members are taxonomically much isolated. In the Old World about 22 species occur, in America four. The chief genus is Rhizophora; Bruguiera (Rhizophoraceae), Avicennia (Verbenaceae), Aegiceras (Myrsinaceae), Sonneratia (Blattiaceae), and *Acanthus ilicifolius* are other important members of the group. In general these plants are much branched, with a great development of aerial roots, both 'flying-buttress' roots from the main stem and supporting 'pillar' roots from the branches. In Sonneratia, Avicennia, and Bruguiera, peculiar erect 'aerating' roots rise out of the mud (p. 161).

The seeds of many mangroves germinate in the fruit (so-called *viviparous* germination) while still attached to the tree, and develope long radicles, which hang down, often to the length of a foot. When the seedling falls the root sticks into the mud or floats tip downwards so that it catches in holes, and thus the danger of being carried away by the tide is lessened. The mangroves are xerophytic in structure with thick fleshy or leathery leaves, thick cuticle, water-tissue, &c.

In Asia and Australia there often occurs, further inland than the mangroves, a vegetation composed chiefly of the 'stemless' palm, *Nipa fruticans*; in America a somewhat similar part is played by Bactris.

Another association in the Old World is the *beach-jungle*, characterised by Barringtonia sp., and by numerous shrubby forms, *e.g.* species of Pandanus, Pemphis, Scaevola, Thespesia, Sophora, Premna, &c. There are also herbaceous associations, mostly on sandy beaches, characterised by *Ipomoea biloba* (*pes-caprae*), *Spinifex squarrosus*, many grasses, &c.

V. Southern temperate zone with hot summers[1]. This includes all the land south of zone IV., except southern

[1] Schimper, &c., *op. cit.*; Hooker, *Introductory Essays*, see p. 140, note; and *cf.* Xerophytes, &c.

Patagonia (and a corresponding belt in the Andes), Kerguelen Island, a belt in the mountains of Tasmania and New Zealand, and the antarctic lands and islands. The vegetative period is interrupted by more or less of winter about July, and in the northern parts there is more or less drought in summer. In Valdivia, Victoria, Tasmania, and part of New Zealand, where there is plenty of rain at all times of the year, there are forests of evergreen and deciduous trees with many Conifers. In Paraguay, Natal and eastern Australia, the forests contain few Conifers; the evergreen trees are mostly much branched. Other areas, *e.g.* in Chili, S.E. Cape Colony, and parts of Australia, are covered by a 'scrub' or 'bush' of evergreen shrubs and small trees, usually of pronounced xerophytic character. The Pampas, the Kalahari desert and much of Australia are covered with a turf of grasses and other xerophytic herbs, which becomes very parched in the dry season.

VI. Southern cold zone[1]. This includes the areas mentioned by name at the beginning of the last paragraph. The vegetation is like that of zone I.—undershrubs, herbs, mosses, lichens, &c.

Floral regions[2]. In the earlier periods of the earth's history the climatic conditions appear to have been very uniform, and the various plants that then existed appear to have had almost universal distribution. This was facilitated by their spores being light and easily carried by wind to great distances (the Cryptogams are the most widely distributed of existing species). Towards the end of the secondary period the boundaries between the different regions of the earth appear to have become more clearly marked, and with them the climatic differences. At the same time the seed-plants, with their less perfect means of dispersal, arose and the flora of the different regions thus became gradually different, the new plants evolved in various districts being checked in their spread over the globe by the various agents discussed above. This process continuing, it has gradually come about that at present the floras of different regions of the earth's surface differ very much in their composition, though they may agree in their general ecological characters;

[1] Schimper, Hooker, &c., *op. cit.*

[2] Cf. Drude, *op. cit.* and other works mentioned above.

the latter, as we have seen, are correlated with the climatal conditions, whilst the composition of the flora is often quite different in regions of similar climate and soil. Thus we are able to divide the earth's surface into a number of *floral regions*, taking no account of ecological characters but only of the relationships of the plants. It is evident from what has been said that a floral region will be characterised by the possession of endemic forms; the greater the number of these and the higher their systematic rank the more natural is the region. Most of the natural orders have a very extensive distribution, and occur in many of the floral regions; the possession of many endemic genera, tribes, and suborders, more or less closely allied, is regarded as sufficient to mark a floral region. The various regions graduate into one another at their edges, and isolated districts belonging to one region often occur in the midst of another (*e.g.* on the mountains). The different regions form three chief divisions, the *boreal* or northern extra-tropical, the *tropical*, and the *austral* or southern extra-tropical. The number and extent of the floral regions of the globe are differently estimated by different writers; we shall follow here the arrangement given by Drude in his *Atlas der Pflanzenverbreitung* (see Map, Frontispiece). Space will only permit of an enumeration of the regions, with their chief characters (abridged from Drude). Each is again subdivided into *domains*.

I. Boreal Group. 1. *The Northern Floral Region* corresponds very closely to the first and second zones of vegetation described above. The general systematic features of the flora resemble those of the British flora. There are forests of Coniferae (Pinus, Picea, Abies, Larix, &c.), Fagaceae (Fagus, Quercus), and Betulaceae (Betula); other common trees and shrubs are species of Acer, Salix, Tilia, Fraxinus, Lonicera, Ilex, Elaeagnus, Crataegus, Prunus, Pyrus, Sambucus, &c. Many Ericaceae, Caryophyllaceae, Ranunculaceae, Compositae, Leguminosae (Papilionatae), Cyperaceae, Gramineae, &c. occur abundantly.

2. *The Central Asiatic Region* includes Turkestan, Mongolia, and Thibet. The district is very dry in summer, and there is much salt in the soil in many parts. Trees are very rare. Halophytes, *e.g.* many Chenopodiaceae, are numerous; other characteristic forms are shrubby species of

Astragalus, and other Leguminosae, Plumbaginaceae, Rheum and other Polygonaceae, large Umbelliferae, &c.

3. *The Mediterranean and Orient Region* includes Spain, southern France, Italy, Greece, Asia Minor, Persia, the Punjab, and Africa and Arabia north of 24° N., together with the Canaries, Azores, &c. It is very closely allied to the preceding region, and possesses a very similar vegetation (*cf.* Zone III. above). A few palms occur here, *e.g.* Chamaerops and the date-palm (Phoenix). There are many Cruciferae, Umbelliferae, Labiatae, Tamaricaceae, &c. : other characteristic forms are *Myrtus communis* (myrtle), *Olea europaea* (olive), *Erica arborea*, *Quercus Ilex*, *Pinus Pinea* and other Conifers, *Platanus orientalis* (plane), *Laurus nobilis* (bay), *Pistacia Lentiscus* (mastic), *Arbutus unedo*, *Castanea vulgaris* (chestnut), &c. Among genera with a large proportion of their species endemic in this region are Anthemis, Astragalus, Allium, Campanula, Centaurea, Cousinia, Hypericum, Salvia, Silene, Verbascum, &c.

4. *The Eastern Asiatic Region* includes the rest of China, with Corea and Japan, and possesses many endemic forms, *e.g.* the Conifers Cryptomeria, Ginkgo, Biota, &c., many Araliaceae, Lardizabalaceae, Menispermaceae, Magnoliaceae, Sapotaceae, &c.

5. *The Central North-American Region* is the region lying between region 1 and the tropical regions of Mexico and the West Indies; it includes the United States with the exception of a part of New England, Washington State and Oregon, and includes also a portion of Canada as far as the Saskatchewan. The climatal conditions resemble those of the Mediterranean region (*cf.* Zone III.). The flora includes many Compositae, Hydrophyllaceae, Polemoniaceae, Nyctaginaceae, Chenopodiaceae, Polygonaceae (§ Eriogoneae), &c. Sequoia and other Coniferae (*q.v.*) characterise the Californian flora; the drier States west of the Mississippi have a xerophytic flora—Cacti or Yuccas in some parts, Artemisias and other halophytes elsewhere (*cf.* above). Juglans, Carya, and other trees mark the Eastern States.

II. Tropical Group. 6. *The Tropical African Region* includes all Africa and Arabia south of region 3, except the Cape-Colony region and the islands on the east side. Palms (notably *Elaeis guineensis*, Raphia, Borassus), Pandanaceae, &c., are common; other characteristic plants are Adansonia, Cola, Butyrospermum, &c. In the south-western deserts occur Welwitschia, Acanthosicyos, and other peculiar forms.

7. *The East African Island Region.* To this belong Madagascar, Mauritius, the Seychelles, Mascarenes, &c. The flora shows relationships to those of both India and Africa. Many endemic forms occur, *e.g.* Lodoicea, Brexia, Chlaenaceae, species of Pandanus, Ravenala, &c.

8. *The Indo-Malayan Region* includes India (except the Punjab), Ceylon, Burmah, Cochin-China, and the islands from Formosa to New Guinea, Polynesia, and northern Australia. Palms, Pandanaceae, Zingiberaceae, Musaceae, Pedaliaceae, Moraceae, Dipterocarpaceae, and other forms abound in this region. Among the characteristic genera are Nepenthes, Tectona, Shorea, Corypha, Caryota, Imperata, and most species of Ficus, Garcinia, Calotropis, Piper, Oryza (rice), &c.

9. *The Tropical American Region.* Beginning in Florida and Central Mexico, this extends over the West Indies, Central America, the Amazon valley, Paraguay, Uruguay, &c. Characteristic orders are the Cactaceae, Loasaceae, Cyclanthaceae, Bromeliaceae, Velloziaceae, Marcgraviaceae, Vochysiaceae, &c. and many genera, *e.g.* Agave, Dasylirion and other Liliaceae, Zea (maize), Phytelephas, Sabal, Oreodoxa, Copernicia, Ceroxylon, Mauritia and other Palms, Carica, Hevea, Theobroma, Victoria, Swietenia, many Compositae, Couroupita, Bertholletia, &c.

III. Austral Group. 10. *The South African Region.* Though small, including chiefly the area south of the Orange River, this region is wonderfully rich in endemic forms and contains a vast number of species. Among the characteristic forms are many Iridaceae, Amaryllidaceae, Liliaceae, Juncaceae (including Prionium), Restiaceae, Ericaceae, Bruniaceae, Penaeaceae, Proteaceae (chiefly Protea and Leucadendron), Selagineae (Scrophulariaceae), Diosmeae (Rutaceae), Acacias, Mesembryanthemum, Helichrysum, Pelargonium, Oxalis, Crassula, and many more.

11. *The Australian Region* includes Australia (except the northern part belonging to region 8) and Tasmania. There are many representative forms of Haemodoraceae,

Candolleaceae, Goodeniaceae, Epacridaceae, Restiaceae, Xyridaceae, Juncaceae, Liliaceae (Xanthorrhea, &c.), Myoporaceae, Myrtaceae (Eucalyptus, &c.), Proteaceae (Banksia, Hakea, Grevillea, &c.), Acacia, Pimelea, Casuarina, Callitris, &c.

12. *The New Zealand Region* comprises New Zealand and a few outlying islands, and contains a very large proportion of endemic species; comparatively few genera are endemic, and these are related to those of Australia, tropical Asia, South America, or the Antarctic region. The ferns form a very characteristic feature in the vegetation. Forests were extensive when the islands were discovered. There are many endemic Coniferae, Compositae, Scrophulariaceae, &c. and the flora contains a small number of European forms.

13. *The Andine Region.* This includes South America south of the Rio de la Plata (except the portion in region 14) and Paraguay, together with the Andes and the coasts of Chili and Peru. There are many shrubby Compositae, also Calyceraceae, Plumbaginaceae, Nolanaceae, Solanaceae, Scrophulariaceae, Escallonias, Tropaeolaceae, Oxalis, &c.

14. *The Antarctic Region.* This corresponds to the sixth zone of vegetation described above. There are many characteristic Gramineae, Juncaceae, Umbelliferae, &c., and such genera as Bolax, Pringlea, Acaena, &c.

CHAPTER IV.

ECONOMIC BOTANY.

ECONOMIC Botany[1] is the study of plants from the point of view of their uses in the arts, manufactures, or commerce. It is largely bound up with agriculture, chemistry, political economy, and other subjects. We shall deal with it here almost solely from the botanical side. As yet the subject is too much in the stage of a heterogeneous assemblage

[1] The literature of Economic Botany is enormous, and the subject is intimately connected with Agriculture, &c. The following are among the more important works of reference on the botanical side: Wiesner, *Die Rohstoffe des Pflanzenreichs*, 2nd ed. Vienna, 1903; Watt, *Dictionary of the Economic Products of India*; F. von Müller, *Select Extra-tropical Plants*; Willis and Wright, *Handbook of Economic Products of Ceylon*, appearing as Supplements to *Ann. Perad.* I, 1901– ; Semler, *Tropische Agrikultur*; Nicholls, *Tropical Agriculture*; De Candolle, *Origin of Cultivated Plants*; Morris, Cantor Lectures on *Plants yielding Indiarubber*, 1898; Obach, Cantor Lectures on *Gutta-percha*, 1897; Seligmann, Lamy, et Falconnet, *Le Caoutchouc et la Guttapercha*, Paris, 1896; Dodge, *A descriptive Catalogue of Useful Fiber Plants of the World*, Washington (U.S. Dept. Agr.), 1897; Hannan, *Textile Fibres of Commerce*, London, 1902; Dragendorff, *Die Heilpflanzen d. versch. Völker und Zeiten*, Stuttgart, 1898; Gamble, *A Manual of Indian Timbers*, 2nd ed. 1903; Bailey, *Cyclopaedia of Horticulture*, *Plant-breeding*; Nicholson, *Dictionary of Gardening*; Sorauer, *Physiology of Plants for Gardeners*; Bateson, *Mendel's Principles of Heredity*. And see such journals as *Kew Bulletin*, *Revue des Cultures Coloniales* (Paris), *Tropenpflanzer* (Berlin), *Schimmel & Co.'s Reports* (Leipzig; essential oils), *Tropical Agriculturist* (Colombo), *Agricultural Ledger* (Calcutta), *Mededeelingen uit's Lands Plantentuin* (Buitenzorg), *Bulletins of the Dept. of Agriculture* (Washington), as well as agricultural and technical journals.

of facts with but few general principles, but with the great attention now being given to it in all parts of the world this will probably soon be altered. We shall deal here mainly with the various classes of vegetable products, their sources, and methods of collection and preparation. For this purpose it is most convenient for the present to use an artificial grouping, chiefly according to the nature and uses of the products, employing eight chief heads, the last of which is a miscellaneous assemblage. For individual products reference should be made to the general index.

I. Gums, Resins, Caoutchoucs, Guttaperchas, &c. These products arise from the drying or coagulation of saps or other excretions, or are obtained from them by distillation or otherwise.

Gums result from the disintegration of the internal tissues, and exude from stems or elsewhere; they are common in plants of dry countries, such as N. Africa or Australia. They are collected from natural or artificial wounds, and usually brought to market in the form assumed by the exudations. They swell or dissolve in water, but are insoluble in alcohol or ether. Chemically, gums may be roughly divided into three classes, according to whether they consist mainly of arabin, bassorin, or cerasin. Arabin is fully soluble in water, and forms the best mucilage; good *gum-arabics* (Acacia spp.) are almost entirely composed of it. Bassorin, of which *gum-tragacanth* (Astragalus spp.) almost entirely consists, is only slightly soluble. Cerasin, which is largely found in cherry gum (Prunus), is insoluble, merely swelling up in water. Gums are used for adhesive purposes, and in calico-printing, sizing, colour-making, confectionery, and pharmacy. Innumerable plants yield gums, but few are of commercial importance except those mentioned.

Resins are the products of secretion or disintegration of the cells or tissues; they are usually formed in special cavities or passages (p. 115). They are commercially collected on a large scale from wounds made in the bark, and are brought to market in the forms assumed by the exudation or in artificial masses. They are insoluble in water, but dissolve in alcohol, ether, or carbon disulphide, and burn with a sooty flame. They may be roughly divided into *resins* proper, *gum-resins* which contain a mixture of gum and resin, and *balsams*, which are more or less fluid, either fluid resins, or resins dissolved in ethereal oils. The chief balsams are those of the Coniferæ (Abies, Pinus, Larix, &c.), commonly known as *turpentines*. When distilled, common resin or rosin is left, and oil of turpentine (often known as, and confused with, true turpentine) passes over. Many Burseraceae, especially Canarium, yield good balsams (*elemis*), and others are given by species of Toluifera, Liquidambar, Styrax, Pistacia, Commiphora, Copaifera, Dipterocarpus, &c. Among the important gum-resins are gamboge (Garcinia), frankincense (Boswellia), and the resins of many species of Ferula, Dorema, Calophyllum, Convolvulus, &c. Of true resins, common resin, some forms of which are known as white pitch and colophony, is obtained from turpentines by distillation, the hard *copals* or *animes* are derived from species of Trachylobium, Hymenaea, Agathis, &c., the *dammars* from Shorea and other Dipterocarpaceae, Canarium and other Burseraceae, &c.; other important resin-yielding genera are Guaiacum, Xanthorrhea, Rhus (Japanese lacquer), &c. The resin of many species of Croton, Ficus, Butea, Schleichera, &c. exudes from punctures produced by the lac insect, and forms the *lac* of East Indian commerce. The chief use of resins is in the manufacture of varnishes, *i.e.* solutions of resins in oil of turpentine, alcohol, or other solvents. Many resins are used in medicine, in lacquer-work, &c.

Kinos are resin-like substances in appearance, but soluble in water, astringent, and used in medicine and in tanning. The chief are yielded by species of Pterocarpus, Butea, and Eucalyptus.

Caoutchouc occurs in suspension in the latex of many trees, especially Euphorbiaceae and Moraceae. When the bark is wounded the latex flows out and a mass of india-rubber is formed by the union of the caoutchouc particles, either by simple drying (with or without gentle heat) or by the use of acetic acid or other coagulants. The most important rubbers are Para (Hevea), Panama (Castilloa), Ceara (Manihot), African (Landolphia), and Lagos (Funtumia). Other genera yielding rubbers are Ficus, Hancornia, Mascarenhasia, Urceola, Willughbeia, &c. On account of its waterproof and extensible qualities, rubber is largely used for tires, balls, shoes, and numerous other purposes; it is usually vulcanised by treatment with sulphur, making it more durable.

Gutta-percha, a somewhat similar substance, but harder when cool, not extensible, and softening with heat, also occurs in latex, chiefly in the Sapotaceae. Species of Palaquium and Payena are the chief sources. It is used in large quantities as an insulator, in the manufacture of golf-balls, and for many other purposes.

Balata, a substance intermediate in properties between gutta-percha and rubber, is obtained from the latex of species of Mimusops.

Camphor, an aromatic crystalline body, is obtained by distillation from the wood or leaves of species of Cinnamomum, Dryobalanops, and Blumea. It is used in the manufacture of celluloid, smokeless powders, &c., and in medicine.

II. Oils. In a vast number of seeds the non-nitrogenous reserves occur as oils (p. 34); these are termed *fixed oils*, and are obtained by pressure, or sometimes by pounding and boiling. Oils also occur in a few fruits or other parts of plants. Ethereal or *volatile oils* are found in many flowers and leaves, &c., often imparting characteristic perfumes to the plants containing them; they are usually obtained by direct steam distillation, or by natural evaporation into a layer of fine fat, which is afterwards treated with alcohol or otherwise to extract the perfume.

Fixed oils are obtained from the following among other genera: Aleurites, Arachis, Argania, Barringtonia, Brassica (rape, colza), Calophyllum, Carya, Cocus (coconut), Corylus, Croton, Elaeis (palm-oil), Guizotia, Gossypium (cotton-seed), Helianthus, Juglans, Linum (linseed), Melia, Moringa, Olea (olive), Papaver, Polygala, Ricinus (castor-oil), Schleichera, Sesamum (gingelly), Theobroma (cacao-butter), Tilia, Vateria, &c. Some of these are drying oils, *e.g.* linseed, used in painting; others remain fluid, while others again are solid at moderately high temperatures, *e.g.* coconut oil in Europe.

Still firmer fatty bodies, used as grease or butter, occur in Bassia, Butyrospermum, Caryocar, Pentadesma, Sapium, &c.; while wax is obtained from Ceroxylon, Copernicia, Myrica, Rhus, &c.

Volatile oils are distilled from Andropogon (citronella, lemon-grass, &c.), Calamintha, Cananga, Cinnamomum (cinnamon, &c.), Citrus (lemon, &c.), Eucalyptus, Eugenia (clove), Gaultheria, Jasminum, Lavandula (lavender), Lippia, Melaleuca, Mentha, Moringa, Nardostachys, Origanum, Pelargonium, Pogostemon (patchouli), Reseda, Rosa, Rosmarinus, Santalum (sandalwood), Sassafras, Thymus, Viola, and many others.

III. Dyes and Tanning-stuffs. Many vegetable dyes are now superseded by artificial products, *e.g.* madder by alizarin, but a large number are still in use. In some cases the colouring matter exists in the plant as such, in other cases it is prepared by oxidation or otherwise. Among the more important plants yielding dyes are Alkanna, Bixa (annatto), Carthamus (rouge), Chlorophora (fustic), Cladrastis, Crocus (saffron), Crozophora, Curcuma (turmeric), Garcinia (gamboge, *cf.* resins), Haematoxylon (logwood), Indigofera (indigo), Isatis (woad), Lawsonia, Maclura (fustic), Morinda, Nopalea (used for feeding cochineal insects), Peganum (turkey red), Reseda, Rhamnus, Rhus, Rubia (madder), &c.

Tannin is contained in many plants and parts of plants; it often occurs in the cells of growing parts, and is then apparently useful in the metabolism. It very often occurs as an excretum in the bark and elsewhere, and it is such parts that are chiefly used as sources of it for commercial purposes. Among the more important genera yielding tan-stuffs may be mentioned Acacia (cutch), Betula, Butea, Byrsonima, Castanea (chestnut), Caesalpinia (dividivi), Gordonia, Pterocarpus (Malabar kino), Eucalyptus, Quercus (oak), Rhizophora, Rhus, Rumex, and many others.

IV. Fibres. Fibres are usually the mechanical tissues of plants (pp. 43, 48), and are arranged at the places where strains occur, the amount of the mechanical tissue developed depending to a considerable extent upon the strain to which the part is subjected. Superficial fibres occur on seeds, leaves, &c.

In the case of stem fibres it is found that those of the bast are longer and more useful than those of the wood, and they alone are used for weaving. They are generally obtained by retting or macerating the stems in water, and afterwards beating out the fibres. The most important fibres of this class are hemp (Cannabis), jute (Corchorus), flax (Linum), sunn-hemp (Crotalaria), rhea or ramie (Boehmeria), &c. In most Monocotyledons the entire vascular bundle is removed by retting or beating of the leaf; important fibres of this class are sisal-hemp and other Agaves, Manila hemp (Musa), Mauritius hemp (Furcraea), New Zealand flax (Phormium), bowstring hemp (Sansevieria), Tillandsia, &c. Many palms have large masses of such fibres at the bases of the leaves, *e.g.* Cocos (coir), Arenga, Attalea, Borassus, Caryota, Copernicia, Jubaea, Leopoldinia (piassaba), Raphia, &c.; these are mainly used for brushes and similar coarse work. The entire leaves of many grasses and sedges, *e.g.* Stipa (esparto), Lygeum, Ampelodesma, Cyperus, &c. are used as fibres in paper-making, basket-weaving, mat-making, &c.; the straw of many cereals, stems of rushes, twigs of osiers and many other plants, the stripped bark of Hibiscus &c., and strips cut from the leaves of many palms, Carludovica, &c., are similarly used, while enormous quantities of paper are made from wood pulp, prepared by macerating the entire wood of stems of conifers, birch, poplar, &c. The chief surface-fibre is cotton (Gossypium); others are found in Eriodendron, Calotropis, Bombax, &c. The entire mass of fibres in the bark of such trees as Lagetta, Antiaris, Broussonetia, is sometimes retted out by natives of tropical countries, and made into rough sacks, dresses, &c. The long tough stems of many lianes are used as ropes. The fibre of the fruit of Luffa forms a scrubbing-brush, and is used for packing, air-filters, &c.

V. Drugs. Innumerable plants are or have been used in medicine, for the sake of the alkaloids and other active principles contained in them. No attempt has been made to mention all these cases nor even all the plants now used. The most important vegetable drugs are probably quinine and opium, but there are numerous others. Among those described in Part II. are Aloe, Alstonia, Amomum, Anamirta, Aralia, Atropa, Cannabis (hemp), Carum, Cascarilla, Cassia (senna), Cinchona (quinine), Cinnamomum (camphor, &c.), Citrullus, Coix, Cola, Colchicum, Colutea, Commiphora, Convolvulus, Croton, Curcuma, Digitalis, Dorema, Drimys, Elettaria (cardamom), Erythroxylon (cocaine), Ferula, Gentiana, Glycyrrhiza (liquorice), Ipomoea, Lewisia, Lindera, Menyanthes, Papaver (opium), Peucedanum, Pilocarpus, Polygala, Pringlea, Rhamnus, Rheum (rhubarb), Ricinus (castor-oil), Ruta, Santalina, Sassafras, Schoenocaulon, Smilax, Strophanthus, Strychnos, Styrax, Tamarindus, Toluifera, Trigonella, Uragoga (ipecacuanha), Urginea, Veratrum, Verbascum, Zingiber (ginger), &c.

As an appendage to drugs may be mentioned *poisons*, *e.g.* Acokanthera, Aconitum, Antiaris, Erythrophloeum, Physostigma, Strychnos, Toxicodendron, &c.; *insect-powders*, *e.g.* Chenopodium, Cimicifuga, Chrysanthemum, &c.; and *soaps*, *e.g.* Chlorogalum, Quillaja, Sapindus, Saponaria.

VI. Edible Products. The life of all animals, including man, depends ultimately upon the food provided by the vegetable kingdom. Animals need proteid materials in their food. Protoplasm of course occurs in all living parts of plants, but is usually accompanied by a disproportionate mass of cellulose, &c., though ruminant animals are able to thrive on such food. The grasses (Gramineae) form the staple food of grazing animals. Among the most useful genera are Agrostis, Alopecurus, Andropogon, Anthoxanthum, Aristida, Avena, Bouteloua, Briza, Bromus, Chionachne, Chloris, Cynodon, Cynosurus, Dactylis, Deschampsia, Eriochloa, Festuca, Holcus, Hordeum, Lolium, Melica, Milium, Panicum, Phleum, Poa, Secale, Tripsacum, Trisetum, Triticum, Zea, &c. Other useful fodder plants are many of the Leguminosae, *e.g.* Acacia, Anthyllis, Astragalus, Ervum, Hippocrepis, Lathyrus (vetch), Lotus, Lupinus, Medicago (lucerne, &c.), Onobrychis (sainfoin), Trifolium (clover), Vicia (vetch), &c., and Symphytum (comfrey), Spergula (spurrey), Atriplex (salt bush, in salt soils), &c.

The staple human food-stuffs, many of which are also used for domestic animals, are obtained from those parts in which the plant has made reserve stores, *e.g.* seeds, tubers, bulbs, &c. The most important food-stuffs are the fruits of the cereal grasses, whose seeds have a starchy endosperm, yielding a flour when ground. The chief are rice (Oryza), wheat (Triticum), oats (Avena), rye (Secale), maize (Zea), barley (Hordeum), to which may be added Coix, Eleusine, Euchlaena, Panicum, Pennisetum, Setaria, Sorghum, Zizania, and others. The seeds of many Leguminosae, which are rich in nitrogen, form valuable food-stuffs, *e.g.* pea (Pisum), bean (Vicia), lentil (Lens), Arachis, Cajanus, Cicer, Dolichos, Glycine, Lathyrus, Phaseolus, Voandzeia, &c. Other important seeds are those of buckwheat (Fagopyrum), coconut (Cocos), chestnut (Castanea), walnut (Juglans), &c., and mention may be made of Araucaria, Bertholletia, Brosimum, Carya, Caryocar, Castanospermum, Corylus, Dioon, Lecythis, Nelumbium, Pistacia, Telfairia, Trapa, &c.

Many fleshy fruits form valuable food-stuffs. Regarded purely as foods probably the most important are the breadfruit and jak (Artocarpus), plantain and banana (Musa), and date (Phoenix), but the following genera also yield fruits of great value: Anona (custard-apple, &c.), Ananas (pineapple), Borassus (Palmyra-palm), Carica (papaw), Citrus (orange, lemon, &c.), Cucumis (melon, cucumber), Cucurbita (pumpkin, marrow), Durio (durian), Eugenia (rose-apple, &c.), Ficus (fig), Fragaria (strawberry), Garcinia (mangosteen), Mangifera (mango); Morus (mulberry), Persea (avocado), Prunus (plum, cherry, apricot, peach, &c.), Psidium (guava), Punica (pomegranate), Pyrus (pear, apple, &c.), Ribes (gooseberry, currant), Rubus (raspberry, blackberry), Vitis (grape), &c. To these may be added a long list of minor fruits, chiefly tropical, and most of which have not, like the above, been improved by cultivation or selection, *e.g.* Aberia, Achras, Anacardium, Artabotrys, Averrhoa, Bactris, Benincasa, Blighia, Byrsonima, Celtis, Cereus, Chrysobalanus, Chrysophyllum, Citrullus, Coccinia, Coccoloba, Debregeasia, Decaisnea, Dialium, Diospyros, Eriobotrya, Eugenia, Feronia, Garcinia, Gaylussacia, Glycosmis, Hymenaea, Juniperus, Lantana, Lapageria, Litchi, Macadamia, Maclura, Mammea, Mimusops, Monstera, Myrtus, Nephelium, Opuntia, Osmanthus, Pappea, Passiflora, Pereskia, Peumus, Sechium, Spondias, Tamarindus, Vaccinium, Vitellaria, Zanthoxylum, Zizyphus, &c.

Underground reserve stores are also an important source of food. The chief are perhaps the tubers of potato (Solanum) and yam (Dioscorea), the rhizomes of arrowroot (Maranta) and taro (Colocasia), the roots of cassava or tapioca (Manihot), sweet potato (Ipomoea), turnip (Brassica), beetroot (Beta), &c., the bulbs of onion, garlic, &c. (Allium), and many more. To these may be added the genera Arum, Alocasia, Canna, Commelina, Daucus, Helianthus, Oxalis, Pachyrrhizus, Peucedanum, Plectranthus, Priva, Raphanus, Scilla, Scorzonera, Selinum, Stachys, Tragopogon, Tropaeolum, Ullucus, Xanthosoma, and others. There are many plants with small tubers or other underground parts that might be improved by cultivation and selection.

Reserves are commonly stored in stems, in trees and shrubs. Starchy food products are obtained from the pith of the stems of sago (Metroxylon) and other palms, Cycas, Alsophila, &c., and sugar from Saccharum, Acer, &c., and from many palms in which the upward current of sap from the reserve stores is tapped for this purpose.

Reserves used as food occur in leaves in cabbages, &c. (Brassica) and in the inflorescences in cauliflower (Brassica). The leaves of many other plants are eaten, but are of no very high food value, *e.g.* celery (Apium), sea-kale (Crambe), lettuce (Lactuca), cress (Lepidium), rhubarb (Rheum), spinach (Spinacia), Ceratopteris, Chenopodium, Eremurus, Foeniculum, Myrrhis, Scorzonera, Tetragonia, &c. The young bud of Oreodoxa and other palms is eaten as cabbage; the young flower heads of the artichoke (Cynara), and the young shoots of Asparagus and some bamboos are also useful vegetables.

Several of these products are rather *condiments* or spices than food. To them may be added many more, *e.g.* mustard (seeds of Brassica), capers (buds of Capparis), cayenne pepper and chillies (Capsicum), caraway (Carum), cinnamon (bark of Cinnamomum), horse-radish (Cochlearia), cloves (buds of Eugenia), cress (Lepidium), nutmeg and mace (Myristica), watercress (Nasturtium), dill (Peucedanum), anise (Pimpinella), pepper (Piper), vanilla (Vanilla), ginger

(Zingiber), Allium, Amomum, Archangelica, Carum, Coriandrum, Crithmum, Cucumis, Cuminum, Illicium, Mentha, Monarda, Monodora, Myrrhis, Ocimum, Olea, Origanum, Pimenta, Salvia, Satureia, Smyrnium, Tropaeolum, Thymus, &c.

Many *drinks* are prepared from plants. Intoxicating liquors are in general prepared by fermentation of liquids containing sugar, *i.e.* the form in which the non-nitrogenous reserve materials are usually transferred from one part of the plant to another (p. 34). When such a plant as Agave, or one of the palms which only flowers once, is producing its inflorescence, there is a great rush of sugar upwards in the stem, and this may be tapped and fermented, *e.g.* in Agave, Borassus, Caryota, Cocos, &c. Other drinks are prepared by fermenting the sugar derived from the starch of seeds in germination, *e.g.* sprouting barley, &c., from reserves in the stems, as in the case of rum from sugar-cane, or from the sugar in fruits, as with wines prepared from grapes (Vitis), &c. Infusion drinks are prepared from the seeds of coffee (Coffea), cacao or cocoa (Theobroma), kola (Cola), &c., and from the leaves of tea (Thea), maté (Ilex), Catha, Priva, Stachytarpheta, &c., and from the root of chicory (Cichorium). The milk of young nuts of Cocos is a useful beverage in the tropics. A milk (latex) is also obtained from Brosimum, &c.

Stimulants and *narcotics* (see also under drugs) are obtained from Areca, hemp (Cannabis), coca (Erythroxylon), kola (Cola), opium (Papaver), tobacco (Nicotiana), &c.

Under this heading may also be mentioned the food plants upon which silkworms are reared, especially the mulberry (Morus); others are Ailanthus, Lactuca, Maclura, &c.

Many plants, especially those belonging to the flower classes, H, B′ and B, and with tubes of about 6 mm. long (*i.e.* corresponding to the length of a hive-bee's tongue), are useful for providing honey and pollen to bees, *e.g.*, Acer, Borago, Brassica, Calluna, Echium, Erica, Eucalyptus, Fagopyrum, Gossypium, Helianthus, Lupinus, Medicago, Melilotus, Mentha, Nepeta, Onobrychis, Origanum, Prunus, Pyrus, Reseda, Ribes, Rosa, Rubus, Salix, Salvia, Thymus, Tilia, Trifolium, Vaccinium, Vicia, Viola, &c. Care has to be taken to avoid plants like Aconitum, with poisonous honey.

VII. Timbers. Ferns and Monocotyledons, with their scattered arrangement of vascular bundles and usual absence of any regular growth in thickness, do not yield much useful wood, or at any rate such as can be sawn into planks, though the entire stems of bamboos, palms, &c. are extensively used in building in the tropics, and split portions are used in roofing, &c. The stems of Arundo, Calamus, &c., furnish canes. The most generally useful timber plants are the Coniferae, their wood being soft and their stems very straight, while the resin acts as a preservative against decay; the chief genera used are Abies, Pinus, Larix, Sequoia, Tsuga, Cedrus, Agathis, Picea, Chamaecyparis, Taxus, &c. There are a vast number of trees of other families also used for timber, some soft-wooded, some hard-wooded; the latter are usually trees of slow growth, and commonly more or less xerophytic. Among the most important genera are Acacia, Acer (maple, &c.), Ailanthus, Albizzia, Artocarpus, Betula (birch), Brya, Bucklandia, Buxus (box), Caraipa, Casuarina, Carya (hickory), Carpinus, Castanea (chestnut), Catalpa, Cedrela, Celtis, Chloroxylon (satinwood), Chickrassia, Corylus, Curtisia, Dalbergia, Diospyros (ebony, &c.), Duguetia, Eucalyptus (gum, jarrah, &c.), Fagus, Flindersia, Fraxinus, Gleditschia, Gmelina, Grevillea, Guaiacum, Hymenaea, Juglans, Liriodendron, Melia, Mesua, Metrosideros, Michelia, Ocotea, Ostrya, Pericopsis, Platanus (plane), Populus, Pterocarpus, Quercus (oak), Rhus, Robinia, Salix, Sambucus, Santalum, Schleichera, Shorea (sal), Swietenia (mahogany), Tectona (teak), Tilia, Tristania, Ulmus, Xylia, Zelkova, &c.

VIII. Miscellaneous useful plants and products. Among products which can scarcely be classified under any of the above heads may be mentioned, *cork* (Quercus), *vegetable ivory* (Phytelephas, &c.), *teasels* (Dipsacus), *weights* and *beads* (Abrus, &c.). Other miscellaneous uses are made of plants in nearly all countries, especially in the tropics.

Ornamental plants may also be mentioned here. Most are cultivated for their flowers; horticulturists endeavour by careful crossing, hybridising and selection to 'improve' them, making the flowers more numerous, the inflorescences more crowded, the plants dwarf, the flowers double or of new colours, and so on. Others, *e.g.* Coleus, Caladium, Codiaeum, are cultivated for their coloured or variegated foliage, or for their handsome leaves.

Many trees are cultivated for ornament or shade, especially in the tropics, where many cultivations are carried on in a partially shaded condition.

PART II.

THE CLASSES, COHORTS, ORDERS, AND CHIEF GENERA OF THE FLOWERING PLANTS AND FERNS.

ALPHABETICALLY ARRANGED UNDER THEIR LATIN NAMES.

EXPLANATORY INTRODUCTION TO PART II.

This part of the book is arranged in alphabetical order, under Latin names. The whole of the classes, cohorts and natural orders are included, as well as several thousand genera, including all the British genera, most of the common European and American genera, and the chief tropical and southern genera. Hardly any important genus has been omitted, and even in studying such a collection as that at Kew, the student will find the majority of the genera treated in this work.

The name of the genus is followed by the abbreviated name of the botanist who so named it, *e.g.* Abelia R.Br. means that Robert Brown was the author of this genus as thus constituted. The names adopted in this work are in general those given in the *Index Kewensis* (Oxford, 1892–5), and a reference to that work will enable the original description of the genus to be found. A list of abbreviations of authors' names is given below. In several cases the name of the genus is due to a pre-Linnaean botanist, *e.g.* Tournefort, and is adopted by Linnaeus; this is indicated thus: Acer (Tourn.) Linn. The same rules apply to the names of the individual species mentioned. A species has always two names, the generic and the specific; *e.g. Abies pectinata* DC. means the species *pectinata* of the genus *Abies*, and indicates at the same time that this plant was so named by De Candolle.

The use of the authority after the name of a plant is rendered necessary by the confusion of nomenclature that exists in Botany. The same species or genus often has two or more names, given to it by different authors or at different times. The usual rule in such cases is to use the name that was first applied to the plant, and to regard the others as *synonyms*; but if this rule be followed up too far, no stability can be assured, and it is customary therefore not to give up a long established name in favour of an older one that has been unearthed by antiquarian research.

The study of systematic botany is rendered much more troublesome than it need be by the number of synonyms that exist, and the same cause has much increased the bulk of this work. An attempt has been made to include the more common and important synonyms. *E.g.* under

Abies, there is a list of names frequently met with in gardens, and opposite to each of these is given the name used in this work; thus *Abies alba* Michx. must be looked for under Picea, *Abies Douglasii* Lindl. under Tsuga, and so on. In the same way the genera are often much confused by synonymy. We have seen (Ch. II.) that it is very difficult to decide when the divergence of two forms is sufficient to entitle them to rank as genera, and this difficulty is the cause of much synonymy. A genus *A* is established by one author, and then it is discovered not to differ sufficiently from another genus *B*, established by the same or another author, to remain as an independent genus. *A* is therefore merged in *B* and becomes a synonym. The species of *A* retain as far as possible their old specific names when placed in *B*. When an entry such as "Abelmoschus Medic. = Hibiscus Linn." is found, it means that the genus Abelmoschus as established by Medicus is merged in Hibiscus of Linnaeus. In this case many of the species have entirely changed their names, *e.g. A. venustus* to *H. spectabilis*; but some have retained their specific names, *e.g. A. splendens* has become *H. splendens*. This latter case is often indicated by putting the name of the old genus in brackets after that of the new, thus, *H.* (*A.*) *splendens*. In many cases the names of some of the genera thus merged in other genera are indicated thus: *Apium* (Tourn.) Linn. (incl. *Helosciadium* Koch); no attempt however has been made to give all such cases or even a fraction of them, but only a few of the more important. In particular those have been given where the genus as here defined differs from the definition in Engler and Prantl's *Natürliche Pflanzenfamilien* by the inclusion or exclusion of other genera. [For further information as to nomenclature see Asa Gray's *Structural Botany*, ch. x.]

The name of the genus is followed by that of the natural order to which it belongs, and after this is often a number (in brackets) indicating the section of the order; thus Abelia belongs to Section III of Caprifoliaceae, Acaena to Section III. 9 of Rosaceae. The general plan upon which the book has been constructed, and the necessity for condensation, render it essential, if the full advantage is to be derived from its use, that the student should refer to the natural order as well as the genus. There he will find the important general characters possessed by the members of the order, and should examine the genus to see in what it agrees, and in what it disagrees, with these. A further reference to the classification given at the end of the article upon the order will point out the special characters to be looked for in the genus as a member of some particular sub-order or tribe. In this way a large amount of information about the particular plant in question may be obtained, and at the same time the student will get into the way of regarding plants not as so many independent and disconnected units, but as related members of one great whole. In this way too he will soon acquire an appreciation of the relative importance of the different characters in classification (see Ch. II) and will learn to recognise the approximate relationships of most plants after a brief inspection, or even at sight.

The natural orders are those given by Engler in his *Syllabus* and in *Die natürlichen Pflanzenfamilien* (see Ch. II), but sufficient reference is made to Bentham and Hooker's system of classification to enable any one who may prefer to use that system, or that of Eichler and Warming, to do so.

The name of the natural order is followed by a statement of the number of species in the genus, and its geographical distribution. The number, unless very small, is always only an approximation; new research is always bringing new species to light, splitting up older ones, or combining two or more into one. This is all the information that is given about a very large number of the genera; only when a genus presents some character of interest which is not common to the order or group, is any particular mention made of it. The biological peculiarities of the most important genera are dealt with pretty fully, but much has been omitted. Thus in dealing with the pollination-methods of flowers a selection of important genera, illustrating the various methods, has been made for description in this part; so too with epiphytes, xerophytes, the morphology of parts, and so on. General discussions of all these subjects will be found in Part I. and numerous examples are there quoted; these examples are mostly dealt with in full in this part. Innumerable cross-references to other articles and to Part I. are made, and should be looked up; those referring to Part II always quote the article and never the page, whilst those referring to Part I always quote the page, so that all references thus: p. 189, refer to Part I.

While in the morphology &c. a selection has thus been made of genera for treatment, this is not the case with economic botany. This has been very fully treated, only a comparatively few genera being omitted. Space, however, has not permitted of a detailed description of economic products or the way in which they are obtained; for this reference must be made to other works (see Ch. IV).

Turning now to the articles upon the natural orders, the same general principles apply to them. After the name of the order is given the cohort in Engler's system to which it belongs. This should be looked up in Ch. II; this will show the orders which are most nearly related to the one under consideration, and the characters that distinguish one from the other can be made out by comparison of their descriptions in Part II. The student should always endeavour to make out why a given order is classified in the position assigned to it. When the order as defined by Engler differs from that defined by Bentham and Hooker, as is so often the case, an attempt should be made to discover the reasons for the difference.

After the position of the order in the system follows the number of its genera and species, the morphology and natural history of its vegetative and reproductive organs, its economic products, and finally, in the case of the more important orders, its classification into sub-orders and tribes, with the more important genera belonging to each. The student should work through this part and study as many of the genera as possible before leaving the order. This is easily managed in dealing with the outdoor collections in our botanic gardens.

No particular attempt is made in this part of the book to avoid technical terms. When a term or abbreviation is used that the reader does not understand he should refer to the Index, where an explanation will be found or a reference made to Part I, in which the terms used are explained.

GENERAL WORKS OF REFERENCE QUOTED.

The following are the chief sources used in the compilation of Part II; they are quoted by abbreviated titles. Most of the abbreviations are obvious; a few of the least obvious are given in brackets below, as well as in the General Index.

Bentham and Hooker, *Genera Plantarum:* London.
Campbell, D. H., *Mosses and Ferns:* London.
Darwin, *Origin of Species*, *Naturalist's Voyage*, and other works.
De Bary, *Comparative Anatomy of the Phanerogams and Ferns*, Engl. ed., Oxford.
De Candolle, *Origin of Cultivated Plants*, Engl. ed.
Drude, *Pflanzengeographie:* Leipzig.
Durand, *Index Generum Phaneragamarum.*
Eichler, *Blüthendiagramme:* Leipzig.
Engler, *Das Pflanzenreich* (*Pfl. R.*)*:* Leipzig (in course of publication); *Syllabus der Vorlesungen.*
Engler and Prantl, *Die Natürlichen Pflanzenfamilien* (*Nat. Pfl.*): Leipzig.
Goebel, *Entwicklungsgeschichte der Pflanzenorgane*, in Schenk's Handbuch; *Organography of Plants*, Engl. ed.; *Pflanzenbiologische Schilderungen.*
Gray, Asa, *Structural Botany:* London.
Hooker, J. D., *Himalayan Journals.*
,, ,, and Jackson, *Index Kewensis*, and the *Supplement* by Durand and Jackson.
Hooker, W. J., *Synopsis Filicum.*
Jackson, *Dictionary of Botanical Terms.*
Kerner and Oliver, *Natural History of Plants*, Engl. ed.
Knuth, *Handbuch der Blütenbiologie.*
Ludwig, *Biologie der Pflanzen.*
Müller, H., *Fertilisation of Flowers*, Engl. ed.: London 1883; *Alpenblumen:* Leipzig, 1881.

Müller, F. von, *Select Extratropical Plants.*
Pax, *Morphologie der Pflanzen.*
Sachs, *Lectures on the Physiology of Plants*, Engl. ed.: Oxford.
Schenck, *Die Wassergewächse.*
Schimper, *Die Epiphytische Vegetation Amerikas*, Jena; *Pflanzengeographie.*
Schumann, *Morphologische Studien.*
The *Treasury of Botany.*
Wallace, *Travels on the Amazon*, *Island Life*, *Darwinism*, *Malay Archipelago*, *etc.*
Warming, *Oekologische Pflanzengeographie*, *Systematic Botany.*
Watt, *Dictionary of Economic Products of India.*
Wiesner, *Die Rohstoffe des Pflanzenreichs:* Leipzig, 1900-03.
And other works mentioned in footnotes in Part I.

BOTANICAL JOURNALS.

There are numerous abbreviated references to the following among other leading Botanical and Agricultural Periodicals.

Agricultural Ledger, Calcutta.
Annales des Sciences Naturelles; Botanique, Paris.
Annales du Jardin Botanique de Buitenzorg, Leyden.
Annals of Botany, London.
Annals of the Royal Botanic Gardens, Calcutta.
Annals of the Royal Botanic Gardens, Peradeniya.
Berichte der deutschen Botanischen Gesellschaft, Berlin.
Botanisches Centralblatt, Leyden.
Botanical Gazette, Chicago.
Botanisch Jaarboek, Ghent.
Botanische Jahrbuch, Engler's, Berlin.
Botanischer Jahresbericht, Just's, Berlin.
Botanical Magazine, Curtis', London.
Botanische Zeitung, Leipzig.
Bulletins, U.S. Department of Agriculture, Washington.
Circulars and Agricultural Journal, Royal Botanic Gardens, Peradeniya.
Cohn's Beiträge zur Biologie der Pflanzen.
Flora, Marburg.
Jahrbuch für wissenschaftliche Botanik, Pringsheim's, Berlin.
Journal de Botanique, Paris.
Journal of Botany, London.
Kew Bulletin, London.
Linnean Society's Journal, London.
Malpighia, Genoa.
Minnesota Botanical Studies, Minneapolis.

Natural Science, London.
Nature, London.
Notizblatt des Botanischen Gartens, Berlin.
Philosophical Transactions of the Royal Society, London.
Pringsheim's Jahrbuch, *see* Jahrbuch.
Revue des Cultures Coloniales, Paris.
Revue générale de Botanique, Paris.
Transactions of the Linnean Society, London.
Tropenpflanzer, Berlin.
Tropical Agriculturist, Colombo.

PART II.

Abatia Ruiz et Pav. Flacourtiaceae (Samydaceae, Benth.-Hooker). 5 sp. trop. S. Am.

Abelia R.Br. Caprifoliaceae (III). 11 sp. As., Mex. United to Linnaea in *Nat. Pfl.*

Abelmoschus Medic. = Hibiscus Linn.

Aberia Hochst. Flacourtiaceae (Bixineae, Benth.-Hooker). 11 sp. Afr., Ceylon. The fruits of *A. caffra* Harv. et Sond. (Kei apple), and others, are edible. United to Doryalis in *Nat. Pfl.*

Abies (Tourn.) Linn. *Synonymy: A. alba* Michx. = Picea alba; *A. alba* Mill. = A. pectinata DC.; *A. americana* Mill. = Tsuga canadensis; *A. californica* Hort. = Tsuga Douglasii; *A. canadensis* Michx. = Tsuga canadensis; *A. canadensis* Mill. = Picea alba; *A. Cedrus* Poir. = Cedrus Libani; *A. Deodara* Lindl. = C. Deodara; *A. Douglasii* Lindl. = Tsuga Douglasii; *A. excelsa* Link = A. pectinata; *A. excelsa* Poir. = Picea excelsa; *A. Kaempferi* Lindl. = Pseudolarix Kaempferi; *A. Larix* Poir. = Larix europaea; *A. montana* Nym. = Picea excelsa; *A. mucronata* Rafin. = Tsuga Douglasii; *A. nigra* Desf. or Duroi = Picea nigra; *A. Omorika* Nym. = Picea Omorika; *A. orientalis* Poir. = Picea orientalis; *A. pectinata* Poir. = Picea rubra; *A. Picea* Lindl. = A. pectinata DC.; *A. Picea* Mill. = Picea excelsa; *A. rubra* Poir. = Picea rubra; *A. vulgaris* Poir. = A. pectinata.

Coniferae (Arauc. 1 b; see C. for genus characters). 20 sp. N. temp. The firs are evergreen trees with needle leaves borne directly on the stems. On the main stem the symmetry is radial, whilst on the horizontal branches the leaves twist so as to get their surfaces all much in one plane (p. 47). If the top bud or *leader* be destroyed, however, a branch bud below it takes up the vertical growth and radial symmetry (p. 20). The cones are large and arranged much like those of Pinus. The female is often brightly coloured, though the C. are wind-fertilised (p. 101). The carpel-scales are large and appear on the outside of the cone between the ovuliferous scales. The cone ripens in one year.

A. pectinata DC. (silver-fir), common in the Mts. of S. Eur., yields a valuable wood, "Strasburg" turpentine (p. 199), &c. *A. balsamea* Mill. (E. N. Am.), the balsam fir, yields the pure form of turpentine known as Canada balsam, used in optical and microscopical work. Many other sp. also yield useful timbers and resins. The firs are handsome trees; among those most commonly cultivated are *A. concolor* Lindl. et Gord. (N. W. Am.), *A. firma* Sieb. et Zucc. (Japan), *A. nobilis* Lindl. (N. W. Am.), *A. Nordmanniana* Spach (Caucasus), *A. Pinsapo* Boiss. (Spain), *A. Webbiana* Lindl. (Himal.).

Abildgaardia Vahl. = Fimbristylis Vahl.

Abobra Naud. Cucurbitaceae (III). 1 sp. temp. S. Am.

Abolboda Humb. et Bonpl. Xyridaceae. 7 sp. S. Am.

Abroma Jacq. Sterculiaceae. 9 sp. trop. As. to Austr. The bark of *A. augusta* L. (Indo-Mal.) yields a good fibre.

Abronia Juss. Nyctaginaceae (I). 12 sp. N. Am. Anthocarp winged.

Abrotanella Cass. Compositae (VII). 12 sp. Rodriguez, Tierra del Fuego, Austr., N. Z., Auckland Is.

Abrus Linn. Leguminosae (III. 9). 6 sp. trop. *A. precatorius* L. has hard red seeds with black tips (crab's eyes), strung into necklaces, rosaries, &c., and used as weights in India. Their colour is said to attract birds, but they are quite inedible (*cf.* Adenanthera). See *Kew Bull.* 1890, p. 1 (Weather Plant).

Absinthium Tourn. ex Linn. = Artemisia Tourn.

Abuta (Barr.) Aubl. Menispermaceae. 23 sp. trop. S. Am. *A. rufescens* Aubl. (Guiana) yields white Pareira root; others yield poisons.

Abutilon Tourn. Malvaceae (II). 80 sp. trop. and warm temp. Many are grown in hot-houses. There is no epicalyx. The mechanism of the flr. is like that of Malva (esp. *M. silvestris*), but in some sp. the flrs. are quite self-sterile; the sta. do not move downwards, but the styles emerge through the mass of anthers, the pollination they thus receive producing no effect. Many sp. are visited by humming-birds (p. 99). *A. Avicennae* Gaertn. (N. temp.), cult. in China, yields the fibre China jute.

Acacia (Tourn.) Linn. Leguminosae (I. 2). 450 sp. trop. and sub-trop., mostly trees (wattles); the typical leaf-form is bipinnate with ∞ leaflets and small scaly stipules. About 300 sp., forming the section *Phyllodineae* (chiefly in Austr. and Polynes.), have simple leaf-like *phyllodes*, *i.e.* petioles flattened so as to place their surfaces vertically—this exposes less surface to radiation. A mere inspection, though it shows the phyllode to be a leaf-structure (it has an axillary bud), does not show that it is not a leaf turned edgewise, though it shows no twist at the base. Occasionally however there are "reversions to type" on the plant, some phyllodes occurring with leaf-blades at their ends, of the ordinary bipinnate type. This is still better seen in germinating seedlings (p. 29). The first leaves are typical bipinnate leaves; they are followed by others with slightly flattened stalks and less blade, and so on, until finally only phyllodes are produced. In *A. alata* R.Br. and others, the phyllodes are decurrent on the stem, like the leaves of thistles. In many sp. the stipules are represented by large thorns, swollen at the base. In *A. sphaerocephala* Cham. et Schlecht. (Cent. Am.), the thorns are inhabited by colonies of ants, which bore into them and clear out the internal tissue. The ants live only on the A. and are fed by it. Extrafloral nectaries occur on the petioles, and curious yellow sausage-shaped 'food-bodies' on the tips of the leaflets. These consist of parenchymatous cells containing food-stuffs, and are eaten by the ants (*cf.* Cecropia). If any attempt be made to interfere with the tree the ants rush out and attack the intruder. A most efficient protection is thus afforded to this myrmecophilous A. (*Cf.* Cecropia, and see *Nature*, Aug. 1893, for an account of the leaf-cutting ants, the chief foes of the A.: and cf. Schimper, *Pflanzengeog.* pp. 147, 170. This was the first case of myrmecophily discovered; see Belt's *Naturalist in Nicaragua.*)

A few A. are twiners, others hook-climbers (p. 172). Most sp. are xerophytes, often forming very characteristic features in the vegetation and scenery, *e.g.* the Babul (*A. arabica* Willd.) with its low, spreading habit, is almost the only tree in many parts of the dry plains of India, and others are common in S. Afr. &c.

The flr. (diagram, see order) has ∞ long sta., affording little protection to the pollen. In *A. homalophylla* A. Cunn. (S. E. Austr.; the Myall) the seed hangs out on a long red funicle which may attract birds.

Many A. yield valuable products. *A. Senegal* Willd. (Soudan) yields gum-arabic; the gum exudes from the branches "principally during the prevalence of the dry desert winds from the N. and E. which blow in the winter after the rainy season." Other species yield inferior qualities of gum. *A. catechu* Willd. (E. Ind.) yields catechu or cutch (used in tanning), by digestion of the wood in hot water. *A. decurrens* Willd. (Austr.; black wattle) yields a good tan-bark; inferior barks are yielded by *A. pycnantha* Benth. (S. E. Austr.; golden wattle), *A. dealbata* Link (Austr.; silver wattle) and others. The wood of many sp. is valuable, especially that of the Australian black-wood, *A. melanoxylon* R.Br. Many have sweetly scented flrs.; those of *A. Farnesiana* Willd. (trop.) are the Cassie flowers of perfumery. *A. armata* R.Br. (temp. Austr.; kangaroo thorn). *A. horrida* Willd. (S. Afr.) and others form good hedges or sand-binding plants.

Acaena Linn. Rosaceae (III. 9). 40 sp. S. Am., Mex., Polynes. Frt. hooked. Some sp. bud from junction of leaf and stalk.

Acalypha Linn. Euphorbiaceae (A. II. 2). 225 sp. trop. The anther lobes are curiously twisted. The stigmas are very large and branched. In *A. indica* L. there are normal ♀ flowers at the base of the infl., then ♂, and at the apex a single ♀ with only one ovule, whose seed has the radicle facing downwards and has no caruncle (Clarke). Several sp. are cultivated for their variegated leaves.

Acampe Lindl. Orchidaceae (31). 10 sp. E. Ind., China, Afr.

Acanthaceae. Dicotyledons (Sympet. Tubiflorae). 134 gen. with 1600 sp., chiefly trop. but also Medit., U.S., Austr., &c. Many biological types occur—climbing plants, xerophytes, marsh plants, &c.—and there is much variety in habit. Trees are rare, most A. being shrubs or herbs with opp. exstip. leaves, usually thin and entire. Infl. most commonly a dichasial cyme, in its ultimate branchings tending to become monochasial, and frequently condensed in the leaf-axils as in Labiatae. Racemose infls. also occur. Bracts and bracteoles usually present, often coloured ; the latter frequently large, more or less enclosing the flr.

Flr. ☿, hypogynous, zygomorphic, usually with a nectariferous disc below the ovary. K (4—5), C (4—5), commonly two-lipped (the upper lip sometimes not developed, *e.g.* in Acanthus). Sta. rarely 5, usually 4 or 2 epipetalous ; staminodes frequently represent the rest of the whorl ; anthers often with one lobe smaller than the other, or abortive ; connective often long (*cf.* Salvia). The pollen exhibits a great variety of patterns (see *Nat. Pfl.*). G (2), 2-loc. with axile placentae each with 2—∞ usually anatropous ovules in two rows. Style usually long with two stigmas. The general arrangement of the flr. for visits of insects, protection of pollen, &c. is like that of Labiatae or Scrophulariaceae.

Frt. a bi-locular capsule (with few exceptions), usually more or less stalked, and loculicidal to the very base. Seeds usually exalbuminous. Their modes of distribution are interesting (see *Nat. Pfl.*). The capsules of Acanthoideae explode and the seeds are thrown out, largely by the aid of peculiar hook-like outgrowths from their stalks (*retinacula* or *jaculators*). Many have superficial scales and hairs which on wetting become mucilaginous and may thus aid in animal-distribution or in anchorage of the seed to its place of germination (*cf.* Linum, Collomia), *e.g.* Crossandra, Ruellia, Blepharis.

Classification and chief genera (after Lindau) :

I. *NELSONIOIDEAE* (Ovules ∞ ; jaculators papilla-shaped) : Nelsonia.

II. *MENDONCIOIDEAE* (Ov. 4, seeds not more than 2. Drupe ; no jac.) : Mendoncia.

III. *THUNBERGIOIDEAE* (Ov. 4. Capsule ; jac. papilla-like) : Thunbergia.

IV. *ACANTHIOIDEAE* (Ov. 2—∞. Capsule ; jac. hook-shaped) :

A. Contortae (cor. convolute, or never ascendingly imbricate) : Strobilanthes, Ruellia, Eranthemum, Barleria.

B. Imbricatae (cor. ascendingly imbricate, or with no upper lip) : Blepharis, Acanthus, Crossandra, Aphelandra, Justicia.

Acanthocarpus Lehm. Liliaceae (III). (Juncaceae Benth.-Hooker). 3 sp. S.W. Austr.

Acantholepis Less. Compositae (XI). 1 sp. W. As.

Acantholimon Boiss. Plumbaginaceae. 80 sp. Orient. Mostly desert plants with spiny leaves (see p. 167).

Acanthomintha A. Gray. Labiatae (VI. 5). 2 sp. Calif.

Acanthopanax Miq. Araliaceae. 6 sp. Ind., Chi., Japan.

Acanthophippium Blume. Orchidaceae (15). 4 sp. Indo-Mal. The axial outgrowth from the base of the column, common in O., is here very great and bends first downwards, then up, removing the insertion of the lateral sepals and labellum to a distance from the column.

Acanthophoenix H. Wendl. Palmae (IV. 6). 3 sp. Mascarenes (p. 195).

Acanthophyllum C. A. Mey. Caryophyllaceae (I. 2). 18 sp. W. As., Siberia. Mostly desert xerophytes with prickly leaves (see p. 167).

Acanthorhiza H. Wendl. Palmae (I. 2). 4 sp. trop. Am. The adventitious roots that spring from the lowest nodes grow normally downwards into the soil, but those from the nodes above develope into numerous thorny branches, and never reach the earth (pp. 39, 40).

Acanthosicyos Welw. Cucurbitaceae (III). 1 sp. S.W. Afr., *A. horrida* Welw., the Narras, a remarkable plant growing on sand dunes (*cf.* Welwitschia, and see p. 195). The root, several inches thick, is very long (up to 40 ft.). Above ground is a thorny shrub, about 3 ft. high, with long tendrils; the thorns are modified twigs. The fruit is eaten by Hottentots. (See Welwitsch, *Trans. Linn. Soc.* 27, 1869.)

Acanthospermum Schrank. Compositae (V). 3 sp. trop. Am., W. Ind.

Acanthostachys Link, Klotzsch, et Otto. Bromeliaceae (I). 1 sp. (*A. strobilacea* L. K. et O.), Brazil, usually placed in Ananas.

Acanthus Tourn. ex Linn. Acanthaceae (IV. B). 20 sp. trop. and subtrop., As., Afr., Eur., mostly xerophytes with thorny leaves (those of *A. spinosus* L. furnished, it is supposed, the pattern for the decoration of the capitals of Corinthian columns). *A. ilicifolius* L. forms part of the mangrove vegetation of trop. As., Afr., &c. (p. 191). Fl. a large bee-flower; there is no upper lip to the corolla, and the protection of the pollen, &c. is undertaken by the calyx. The anthers form a box by fitting closely together at the sides, and shed their pollen sideways into it, where it is held by hairs till an insect probing for honey forces the filaments of the sta. apart and receives a shower of pollen on its head (*cf.* many Scrophulariaceae, Ericaceae, &c.). In the young flr. the style is behind the anthers, later on it bends down so as to touch a visiting insect. The frt. explodes and there are large 'jaculators' on the seeds.

Acer (Tourn.) Linn. Aceraceae. 110 sp. N. temp., esp. in mountain or hill districts (*A. pseudoplatanus* L., the sycamore, and *A. campestris* L., the maple, in Brit., the latter native) and trop. mts. There are many sp. in S.W. China and Japan. Trees and shrubs, with opp. exstip. leaves, deciduous or evergreen. Leaf in some simple entire, more commonly 3- or 5-lobed, occasionally compound. An interesting exercise is to go through a collection of A. in an herbarium or elsewhere, comparing the leaf-tips as to degree of development of the acuminate "drip-tips" (*cf.* Ficus, and see p. 143) noting at the same time the kind of climate from which each specimen has come. There is a good general correlation between the length of tip and wetness of climate.

Large winter buds are formed, covered by scale leaves. In many sp. transitional forms may be seen as the bud elongates in spring (*cf.* p. 20), between the scales and the green leaves, showing that the scale is the equivalent, not of the whole leaf, but of the leaf base. In Negundo, often united to A., there are no scales, but the bud is protected by the base of the petiole of the leaf in whose axil it arises.

The leaves of the maple commonly exhibit varnish-like smears, of sticky consistence, known as *honey-dew*. This is the excretion of the aphides which live on the leaves; the insect bores holes into the tissues, sucks their juices, and ejects a drop of honey-dew on an average once in half-an-hour. In passing under a tree infested with aphides one may sometimes feel the drops falling like a fine rain (see Pithecolobium). The fluid is rich in sugar. When the dew falls the hygroscopic honey-dew takes it up and spreads over the leaf; then later in the day evaporation reduces it to the state of a varnish on the leaf surface, which aids in checking transpiration. Many other trees exhibit this phenomenon, *e.g.* lime, beech, oak, &c. (see Büsgen, *Der Honigthau*, Jena: Fischer).

Flrs. in racemes, sometimes contracted to corymbs or umbels, regular, polygamous, not very conspicuous. The formula is usually K5, C5, A4 + 4, G (2). There is usually a well-marked honey-secreting disc. Apetaly occurs in some sp. 3 cpls. are frequently met with, especially in the end flr. of a raceme. The ☿ flrs. are protandrous, but the fertilisation methods and still more the sex-distributions and their causes, deserve further investigation.

In germination, the long green cotyledons come above the soil almost at once, and perform assimilatory duties.

A. saccharum Marshall (*A. saccharinum* Wangenh.) and other sp. of the E. U. S. yield maple sugar, obtained by boring holes in the tree in February and March and collecting and evaporating the escaping juice. Many sp. yield good timber. A number of Japanese sp., with prettily shaped or variegated leaves, are cultivated as ornamental shrubs.

Aceraceae. Dicotyledons (Archichl. Sapindales). 3 gen. (Acer, Negundo, Dipteronia) with 112 sp. N. temp. (esp. in hills) and trop. mts. Trees and shrubs; leaves opp., petiolate, exstip., simple entire or more often palmately lobed or compound. Infl. racemose, corymbose, or fasciculate.

Flrs. regular, andromonœcious, androdiœcious, diœcious, &c., 5-4-merous, usually dichlamydeous. Disc annular or lobed or reduced to teeth, rarely absent. A. 4—10, usually 8; ♂ flr. with rudimentary G. $\underline{G}$ (2), 2-loc., laterally compressed; styles 2, free or joined below; ovules 2 in each loc., orthotropous to anatropous, with dorsal raphe. Fruit of 2 samaras, separating when ripe. Seeds usually solitary, exalbuminous, the cotyledons irregularly folded. Many sp. yield good timber, sugar, &c. (*cf.* Acer). Placed in Aesculinae by Warming, united to Sapindaceae by Benth.-Hooker.

Aceranthus Morr. et Dcne. Berberidaceae. 3 sp. Chi., Japan. United to Epimedium in *Nat. Pfl.*

Aceras R.Br. Orchidaceae (3). 1 sp. Eur. (incl. Brit.), *A. anthropophora* R.Br., the man-orchis. Like Orchis.

Acetosa Tourn. ex Mill. = Rumex Linn.

Acetosella Moehr. = Oxalis Linn.

Acharia Thunb. Passifloraceae (*cf.* Achariaceae). 1 sp. S. Afr.

Achariaceae. A sub-order of Passifloraceae, differing chiefly in the slight development of the receptacle, and in possessing sympetalous flrs.; sometimes raised to ordinal rank.

Achillea Linn. Compositae (VII). 80 sp. N. temp. *A. Millefolium* L. (yarrow or milfoil) common in Brit., *A. Ptarmica* L. (sneezewort) frequent. The flrs. have very short tubes and are visited by less highly specialised insects than most of the order.

Achimenes P.Br. Gesneraceae (II). 25 sp. trop. Am.

Achlamydosporeae (Benth.-Hooker). The sixth series of Monochlamydeae (p. 136).

Achlys DC. Berberidaceae. 2 sp. Japan and Pacif. N. Am. The flrs. have no perianth; it aborts early in development.

Achras Linn. Sapotaceae (I). 1 sp., *A. Sapota* L., W. Ind., trop. Am., cultivated, for its edible fruit, the Sapodilla plum. The resinous latex, when coagulated, forms chiele gum, used in the U.S. for making statuettes, and for other purposes.

Achyrachaena Schau. Compositae (V). 1 sp. N.W.U.S. Pappus of broad, silvery scales; fruit-heads used as "everlastings."

Achyranthes Linn. Amarantaceae (2). 15 sp. trop. and sub-trop.

Achyrocline Less. Compositae (IV). 25 sp. Madag., trop. Afr. and Am.

Achyrophorus Adans. = Hypochaeris Linn.

Achyrospermum Blume. Labiatae (VI, 4). 7 sp. trop. Afr. to Malay Is.

Aciachne Benth. Gramineae (VIII). 1 sp. trop. S. Am.

Acianthus R.Br. Orchidaceae (4). 7 sp. Austr., N.Z., New Caled. Eight pollinia.

Acicarpha Juss. Calyceraceae. 3 sp. temp. S. Am.

Acidanthera Hochst. Iridaceae (III). 16 sp. trop. and S. Afr.

Acineta Lindl. Orchidaceae (19). 10 sp. Cent. Am., Mexico, epiphytic. There is an outgrowth of the axis carrying out the labellum and 2 sepals. The labellum is attached to the column.

Acinodendron Kuntze = Miconia Ruiz et Pav.

Aciotis D. Don. Melastomaceae (I). 30 sp. trop. Am., W. Ind.

Aciphylla Forst. Umbelliferae (6). 13 sp. Austr., N.Z.

Acisanthera P.Br. Melastômaceae (I). 20 sp. trop. Am., W. Ind.

Acleisanthes A. Gray. Nyctaginaceae (I). 5 sp. Mex., Texas.

Acmadenia Bartl. et Wendl. f. Rutaceae (IV). 14 sp. S. Afr.

Acmella Rich. = Spilanthes Jacq.

Acnida Linn. Amarantaceae (2). 3 sp. U.S. Diœcious.

Acnistus Schott. Solanaceae (II). 14 sp. trop. Am.

Acokanthera G. Don. Apocynaceae (I. 1). 3 sp. Abyss., S. Afr. The root and wood of *A. venenata* G. Don supply the Zulus with their arrow-poison.

Aconitum Tourn. ex Linn. Ranunculaceae (2). 60 sp. N. temp. *A. Napellus* L. (aconite, monkshood) in Brit. Flrs. in racemes (see order). The posterior sepal forms a large hood, enclosing the two "petals" which are represented by nectaries on long stalks. Flr. protandrous, adapted, by its structure and its blue colour, to bees. The distribution of A. is largely determined by that of the humble-bee (Bombus), the limit of the former being within, but close to, that of the latter, except in S. Am., where there are Bombi but no A. (See Drude, *Pflanzengeog.*) Humble-bees often rob the flr. of its honey by biting through the hood. The fruit consists of follicles which only open so far as to expose the seeds, which escape when shaken by wind or otherwise (censer-mechanism, p. 110). All sp. are poisonous; the tuberous roots contain alkaloids of the Aconitin group (used in medicine). The root of *A. ferox* Wall. furnishes the Bikh poison of Nepal.

Acorus Linn. Araceae (I). 2 sp. N. temp. and S.E. As. *A. Calamus* L. (sweet flag) in Brit. Rhizome sympodial; leaves isobilateral. Flr. ☿, protogynous, with perianth. The plant has an aromatic scent.

Acotyledones (Jussieu) = Cryptogamae.

Acranthera Arn. Rubiaceae (I, 7). 6 sp. Indo-Mal.

Acridocarpus Guill. et Perr. Malpighiaceae (I). 11 sp. Afr., Madag., N. Caled.

Acrocarpus Wight. Leguminosae (II, 7). 3 sp. Indo-Mal.

Acrocephalus Benth. Labiatae (VIII). 30 sp. Malay Arch. to trop. Afr.

Acroclinium A. Gray = Helipterum DC.

Acrocomia Mart. Palmae (IV, 7). 10 sp. trop. Am., W. Ind.

Acrogamae = Porogamae. See Chalazogamae.

Acroglochin Schrad. Chenopodiaceae (A. 2). 1 sp. N. India, China. The fruit mass is prickly, many of the twigs not ending in flrs.

Acronychia Forst. Rutaceae (IX). 17 sp. trop. As., Austr.

Acropera Lindl. = Gongora Ruiz et Pav.

Acrostichum Linn. Polypodiaceae. About 150 sp. trop., mostly in wet places.

Acrotrema Jack. Dilleniaceae. 12 sp. Ceylon, India.

Actaea (Tourn.) Linn. (excl. *Cimicifuga* Linn.). Ranunculaceae (2). 3 sp. N. temp. *A spicata* L., (bane-berry or herb-christopher) in Brit. Flrs. in racemes (*cf.* Aconitum). Cpl. 1. Berry.

Actephila Blume. Euphorbiaceae (A. I. 1). 10 sp. Indo-Mal., Austr.

Actinella Nutt. Compositae (VI). 17 sp. Am.

Actinidia Lindl. Dilleniaceae (Ternstroem. B. and H.). 8 sp. E. As.

Actiniopteris Link. Polypodiaceae. 1 sp. Ind., Ceylon, Afr., Masc. It has the habit of a small palm with fan leaves.

Actinodaphne Nees. Lauraceae (I). 50 sp. E. Ind., Japan, N. Am.

Actinolepis DC. Compositae (VI). 9 sp. West U.S. Joined to Baeria in *Nat. Pfl.*

Actinomeris Nutt. Compositae (V). 2 sp. Atl. U.S.

Actinostemma Griff. Cucurbitaceae (I). 4 sp. Ind. to Japan.

Actinostrobus Miq. Coniferae (Arauc. 2 a; see C. for genus characters). 1 sp. *A. pyramidalis* Miq., in S.W. Australia.

Ada Lindl. Orchidaceae (28). 1 sp. Colombia.

Adamia Wall. = Dichroa Lour.

Adansonia Linn. Bombacaceae. 3 sp. Afr., Austr. *A. digitata* L. is the Baobab, one of the largest trees known. Its height is not great, but it has a very stout trunk, as much as 30 ft. thick. The fruit is woody, containing a pulp in which lie the seeds.

Adenandra Willd. Rutaceae (IV). 25 sp. E. Afr.

Adenanthera Royen. Leguminosae (I. 4). 3 sp. trop. As. and Queensland. The seeds are hard and bright red (cf. Abrus).

Adenia Forsk. = Modecca Linn.

Adenocarpus DC. Leguminosae (III. 3). 10 sp. Medit.

Adenophora Fisch. Campanulaceae (I. 1). 10 sp. temp. Eur., As.

Adenostemma Forst. Compositae (II). 6 sp. trop. Am.

Adenostoma Hook. et Arn. Rosaceae (III. 7). 2 sp. Calif. *A. fasciculata* H. et A. is the shrub forming the "Chaparral" of the Sierras, so often mentioned in stories of adventure (p. 188).

Adenostyles Cass. Compositae (II). 5 sp. Alpine, Eur., As. Minor. Also a synonym of Zeuxine (Orchidaceae).

Adesmia DC. (*Patagonium* Schrank.) Leguminosae (III. 7). 90 sp. S. Am.

Adhatoda Tourn. Acanthaceae (IV. B). 6 sp. trop.

Adiantum Linn. Polypodiaceae. About 70 sp., esp. trop. Am. *A. Capillus-veneris* L., the maiden-hair fern, occurs wild in a few spots in Brit. Many sp. of maiden-hair are favourite hot-house plants. Several tropical sp. are climbing epiphytes.

Adinandra Jack. Theaceae. 13 sp. trop. As., Afr.

Adlumia Rafin. Papaveraceae (III). 1 sp. E. N. Am. A leaf-climber.

Adonis Dill. Ranunculaceae (3). 20 sp. N. temp. *A. autumnalis* L., the pheasant's eye, is a rare cornfield weed in Britain.

Adoxa Linn. Adoxaceae. *A. moschatellina* L., the moschatel, is the only sp. It is found in the N. temp. zone, including Britain. There is a creeping monopodial rhizome, bearing a flowering shoot with a few radical leaves, a pair of opposite cauline leaves and a small head of greenish flowers, usually 5 in number (a condensed dichasial cyme). The terminal flower is usually 4-merous, the laterals 5-merous (cf. Ruta and other plants). Flowers ☿, regular, greenish and inconspicuous. There is a perianth of two whorls, the outer usually 3-merous; it is sometimes regarded as an involucre formed of bract and bracteoles, but is very probably a calyx. Sta. alternate with petals, divided almost to the base. Cpls. (3—5) rarely (2). Ovary semi-inferior with one pendulous ovule in each loculus. Fruit a drupe with several stones.

Honey is secreted round the top of the ovary. The chief visitors are small flies, attracted by the curious musky smell.

Adoxaceae. Dicotyledons (Sympet. Rubiales). Only genus Adoxa (*q.v.*). Bentham and Hooker unite the order with the Caprifoliaceae, and other authors place it near to the Saxifragaceae. Its relationships to any order are not very close (see Schumann, *Morph. Studien*).

Aechmea Ruiz et Pav. Bromeliaceae (I). 50 sp. epiphytes, W. Ind. and S. Am.

Aegiceras Gaertn. Myrsinaceae (IV). 1 sp. *A. majus*, trop. Old World. It grows in mangrove swamps together with Rhizophora, &c., and exhibits a similar habit, vivipary, &c.

Aegilops Linn. = Triticum L.

Aegiphila Jacq. Verbenaceae (IV). 30 sp. trop. Am.

Aegle Correa. Rutaceae (X). 2 sp. Indo-mal.

Aegopodium Knaut. Umbelliferae (5). 2 sp. Eur., As. (1 Brit.).

Aegopogon Beauv. Gramineae (III). 2 sp. Braz. to Calif.

Aerides Lour. Orchidaceae (31). 15 sp. E. As. Epiphytes; leaves fleshy.

Aeschynanthus Jack. (*Trichosporum* Don.) Gesneraceae (I). 70 sp. Indo-mal., China. Many are epiphytes with fleshy leaves. The flrs. show extreme protandry with movement of the sta. The seeds are provided with long hairs.

Aeschynomene Linn. Leguminosae (III. 7). 50 sp. trop. (Herminiera is often united with A., *e.g.* in *Nat. Pfl.*)

Aesculinae. A cohort in Eichler's (Warming's) classification (p. 137).

Aesculus Linn. (including *Pavia* Poir. and *Billia* Peyr.) The only genus of Hippocastanaceae. 16 sp. N. temp. and Venezuela, &c. *A. Hippocastanum* L. is the horse-chestnut, which, with several sp. of the sub-genus Pavia, is commonly grown as an ornamental tree. *A. ohioensis* Michx. (= *glabra* Willd.) is the Buckeye of the U.S. They are trees with very large winter buds, covered with resinous scale leaves and containing the next year's shoot in a very advanced state (including the infl.). The bud expands very rapidly in spring. In *A. parviflora* Walt. transitions from scales to perfect leaves may be seen, showing the former to be the equivalent of leaf-bases. The leaves are opp. exstip. palmate; the blades when young hang downwards and are hairy. The infl. is mixed, the primary structure being racemose, but the lateral branches cymose (cincinni). The upper flowers are ♂, with rudimentary ovary, and open first. The ☿ flowers are protogynous, and when they open the ripe stigma protrudes whilst the sta. are bent down; later on these move up to a level with the style. Self-fert. may occur. The chief visitors are bees. On the corolla when young are yellow spots, which later on turn red (cf. Fumaria, Diervilla, &c.). The formula of the flr. is K (5); C 5 or 4 zygom.; A 8-5 introrse; disc extrastaminal, often one-sided. $\underline{G}$ (3), 3-locular, with 2 ovules in each loc. Fruit a leathery capsule, usually one-seeded, 3-valved. Seed large exalbuminous. (Cf. this fruit with that of Castanea.)

Aethionema R.Br. (incl. *Eunomia* DC.). Cruciferae (II. 6). 50 sp. Medit.

Fruit lomentose in some sp.; in others, *e.g.* *A. heterocarpa* J. Gay, there are two kinds of fruit, one many-seeded and dehiscent, the other one-seeded indehiscent.

Aethusa Linn. Umbelliferae (6). 1 sp. *A. Cynapium* L. Brit. Eur. (fool's parsley).

Afzelia Sm. (*Intsia* Thou.) Leguminosae (II. 3). 8 sp. trop. As. Afr.

Agapanthus L'Hérit. Liliaceae (IV). 3 sp. S. Afr. *A. umbellatus* L'H. is common in gardens. Infl. a cymose umbel. Seeds winged.

Agapetes G. Don. Ericaceae (III. 8). 30 sp. Nepal to Australia.

Agathaea Cass. = Felicia Cass. United to Aster.

Agathis Salisb. (*Dammara* Lam.) Coniferae (Arauc. 1 a; see C. for genus characters). 4 sp. Malay to N. Z. Evergreen diœcious trees: the fruit takes two years to ripen. *A. Dammara* Rich. (*D. orientalis* Lamb.), in Malay and Phil. Is., yields a Dammar-resin largely used in varnish-making, &c. *A. australis* Steud. in Austr. and N. Z., is the Kauri or Cowrie pine, yielding a similar resin (Kauri-copal or dammar); the best pieces are dug out of the soil, often at a distance from any trees now living.

Agathosma Willd. Rutaceae (IV). 100 sp. S. Afr.

Agave Linn. Amaryllidaceae (II). 50 sp. trop. Am. The so-called Century plant or American Aloe (*A. americana* L.) is the most familiar sp. There is a short stem, which grows in thickness in a similar manner to the stem of Yucca, bearing a rosette of large fleshy leaves, coated on the surface with wax. Only two or three of these are formed in a year. During a period of from five to 100 or more years, depending on climate, the richness of the soil, &c. the plant is purely vegetative, and stores up in these leaves an enormous mass of reserve materials. At length it flowers, a gigantic terminal infl. coming rapidly out, sometimes reaching a height of 20 feet, and bearing many flowers. When the berries are ripe the reserves are exhausted, and the plant dies; it is thus an "annual" in a sense. The rush of sap to so large and so rapidly developed an inflorescence is of course very great; the Mexicans utilise it by cutting off the young flower head and collecting the sap (as much as 1000 litres have been got from one plant). The fermented juice is the national drink "pulque." The plant is also useful in many other ways, yielding fibre, &c. *A. rigida* Mill. yields the fibre "Sisal hemp," now largely used in rope making.

Vegetative reproduction occurs in two ways—by suckers from the base of the stem, and by bulbil-formation in place of some of the flowers.

Ageratum Linn. Compositae (II). 30 sp. trop., all but one Amer.

Aggregatae Engler. The 8th cohort of Dicot. Sympet. (see p. 131). Ditto Eichler (Warming). The 10th cohort of Sympet. (see p. 138).

Aglaia Lour. Meliaceae. 60 sp. Ind. to Austral.

Aglaonema Schott. Araceae (v). 10 sp. E. Ind. There are several infl. forming a sympodium. Flr. monoecious, naked.

Agonis Lindl. Myrtaceae (2). 13 sp. Austr.

Agrimonia Tourn. Rosaceae (III. 9). 10 sp. N. temp. *A. Eupatoria* L. and *A. odorata* Mill. (agrimony) in Brit. The recept. encloses the two achenes in frt. and is covered with hooks for animal carriage.

Agropyron J. Gaert. Gramineae (XII). 32 sp. temp. *A. caninum* Beauv. and *A. repens* Beauv. occur in Brit. The latter is the twitch or couch grass, a very troublesome weed in agriculture. It has a long rhizome, rooting at the nodes. If broken up by plough or harrow each node gives rise to a new plant, hence it is very hard to eradicate.

Agrostemma Linn. = Lychnis L.

Agrostis Linn. Gramineae (VIII). 100 sp. chiefly N. temp. 4 Brit. sp., including *A. alba* L. the white Bent- or Fiorin-grass, a valuable pasture grass with a creeping stem that roots at the nodes.

Ailanthus Desf. Simarubaceae. 4 sp. Ind., Chi., Austr. *A. glandulosa* Desf., the tree of heaven, is a favourite in parks. Absciss layers are formed at the base of the leaflets as well as of the main petiole; the former usually drop first. Buds are formed on the roots (?).

Ainsliaea DC. Compositae (XII). 16 sp. Ind. to Japan.

Ainsworthia Boiss. = Tordylium L.

Aira Linn. Gramineae (IX). 11 sp. chiefly Eur., Afr. 2 sp. in Brit. (for *A. caespitosa* L. and *A. flexuosa* L. of Brit. flora, see Deschampsia, and for *A. canescens* L. see Corynephorus).

Aizoaceae (*Ficoideae* of Benth.-Hook.). Dicotyledons (Archichl. Centrospermae). 18 gen. with 420 sp. chiefly S. Afr. They are nearly allied to the other Centrospermae, but have been placed in various other relationships by other authors (near Cactaceae by B. and H.). Xerophytic herbs with opp. or alt. exstip. leaves, often fleshy, and with cymes of flowers. The anatomy is of interest (see *Nat. Pfl.*). The typical formula, according to Pax, is P 5 (odd leaf posterior); A 5; $\underline{G}$ (3), 3-locular with ∞ ovules in each. In the androeceum, dédoublement is very common, and in these cases the outer sta. are frequently represented by petaloid staminodes (*e.g.* Mesembryanthemum). The ovary is usually sup. with axile plac. but in M. it is inf., multiloc. with parietal plac., a very unusual feature, brought about during development (see M.). Fruit usually a capsule; seed albuminous with curved embryo.

Classification and chief genera (after Pax):

I. *MOLLUGINOIDEAE* (perianth deeply 5-lobed: 'petals' or not: ov. sup.): Mollugo, Orygia.

II. *FICOIDEAE* (perianth tubular):

1. *Sesuvieae* (ov. sup.; caps. with lid): Sesuvium, Trianthema.
2. *Aizoeae* (do.; caps. splitting): Galenia, Aizoon.
3. *Mesembryanthemeae* (ov. inf.): Tetragonia, Mesembryanthemum.

Aizoon. Aizoaceae (II. 2). 10 sp. Afr., Medit. Sta. ∞ in bundles.

Ajuga Linn. Labiatae (I. 1). 30 sp. temp. *A. reptans* L. the bugle, and two others in Brit. The corolla has no upper lip, the sta. being protected by the bract above. Vegetative reproduction by runners.

Akebia Dcne. Lardizabalaceae. 2 sp. China, Japan. *A. quinata* Dcne. is often cultivated. Its flrs. are monœcious, the lower in the raceme usually ♀. The ♀ is much larger than the ♂, a very unusual thing. The berries dehisce like follicles.

Alangium Lam. Cornaceae. 4 sp. Malaya.

Albizzia Durazz. Leguminosae (I. 1). 50 sp. trop. and sub-trop. Old World. *A. Lebbek* Benth., and others, yield valuable timber.

Albuca Linn. Liliaceae (V). 30 sp. Afr. Outer sta. often staminodes.

Alchemilla Linn. Rosaceae (III. 9). 40 sp. temp. Flr. inconspicuous, with epicalyx, apetalous; sta. 2 or 4; cpls. 1—4, each with 1 ovule. Achenes enclosed in dry recept. *A. arvensis* Scop (parsley-piert), *A. vulgaris* L. (lady's mantle) and *A. alpina* L. occur in Brit. The last covers large areas in the Highlands; it has hairy leaves, more divided than those of the preceding sp., and the change from one type to the other is very noticeable in ascending the hills. The flrs. of all Brit. sp. are visited by flies.

Alchornea Sw. Euphorbiaceae (A. II. 2). 30 sp. trop. *A.* (*Coelebogyne*) *ilicifolia* Müll.-Arg. is only cultivated in the female form, but produces good seed. Adventitious embryos are formed by budding of the nucellus-tissue round the embryo-sac (cf. Funkia).

Aldrovanda Monti. Droseraceae. 1 sp. *A. vesiculosa* L. Eur., As. It is a rootless swimming plant, with whorls of leaves. Each of these has a stalk portion and at the end of this a few bristles and a blade like that of Dionaea (*q.v.*) provided with glands and trigger hairs. Mucilage is also secreted by stellate hairs on the leaf. Small water animals are captured and digested as in Dionaea (see Darwin, Goebel, &c. and p. 178). Winter buds (p. 159) are formed in colder climates.

Aletris Linn. Liliaceae (IX). 8 sp. E. As. and N. Am.

Aleurites Forst. Euphorbiaceae (A. II. 3). 5 sp. trop., sub-trop. Extrafloral nectaries occur on the petiole and at the ends of the large leaf-veins (see Groom, *Ann. of Bot.* 1894). The seeds yield an oil.

Alfredia Cass. Merged in Carduus Linn. (same spec. names).

Alhagi Tourn. Leguminosae (III. 7). 3 sp. Steppes and Medit. Thorny xerophytes. In the dry season the rootstock is blown about by the wind. A honey-like sap exudes from all sp. in hot weather, hardening into brownish lumps during the night (manna).

Alibertia A. Rich. Rubiaceae (I. 8). 20 sp. trop. Am.

Alisma Linn. (incl. *Caldesia* Parl.). Alismaceae. 6 sp. cosmop. *A. Plantago* L., the water-plantain, in Brit. Sta. 6, due to doubling of outer whorl, coherent at the base, forming a nectary. For *A. natans* L. see Elisma.

Alismaceae. Monocotyledons (Helobieae). 10 gen. with 50 sp. temp.

and trop. Mostly water or marsh herbs with perennial rhizomes. Leaves various, erect, floating, or submerged and exhibiting structure corresponding to their conditions of life (see p. 160 and Sagittaria, Elisma, &c.). In the leaf axils are small scales. Laticiferous vessels occur. Infl. usually much branched, the primary branching racemose, the secondary often cymose. Flr. ☿ or ♂ ♀, regular, with perianth of 6 leaves in two whorls, the outer sepaloid, the inner petaloid. Sta. 6–∞, with extrorse anthers. Cpls. 6–∞, apocarpous, superior, with 1 (rarely 2 or more) anatropous ovule in each. Fruit a group of achenes; seed exalbuminous; embryo horse-shoe shaped.

Chief genera: Alisma, Elisma, Damasonium, Sagittaria. [Benth.-Hook. unite A. with Butomaceae, placing them in Apocarpae.]

Alkanna Tausch. Boraginaceae (IV. 3). 30 sp. Medit. &c. The root of *A. tinctoria* L. furnishes the red dye, alkanet or alkannin.

Allamanda Linn. Apocynaceae (I. 1). 12 sp. trop. Am. and W. Ind.

Alliaria Marsh. = Sisymbrium L. (*A. offic.* DC. = *S. Alliaria* Scop.).

Allionia Loefl. Nyctaginaceae (1). 1 sp. Am. Anthocarp glandular (cf. Pisonia).

Allium (Tourn.) Linn. Liliaceae (IV). About 250 sp. N. temp. *A. ursinum* L. (garlic), *A. Schoenoprasum* L. (chives), and 6 others, in Brit. *A. Cepa* L. (Persia, &c.) is the onion, *A. Porrum* L. (Eur.) the leek, *A. ascalonicum* L. (Orient) the shallot, *A. sativum* L. (S. Eur.) the garlic. All are bulbous herbs with linear (or hollow centric) leaves and cymose umbels of flrs. In many sp. the flrs. are replaced by bulbils serving for vegetative reproduction (cf. Lilium). In *A. ursinum*, &c. honey is secreted by the septal glands of the ovary; the protandrous flr. is visited by bees and flies.

Alloplectus Mart. (*Crantzia* Scop.) Gesneraceae (I). 35 sp. trop. Am.

Allosorus Bernh. = Cryptogramme R. Br.

Almeidea St. Hil. Rutaceae (V). 10 sp. Brazil.

Alnus (Tourn.) Linn. Betulaceae. 14 sp. N. temp. (*A. glutinosa* Medic., the alder, in Britain.) Like Betula in most features. In the axil of each bract of the ♂ catkin are 3 flowers (see diagram of the order, and cf. other genera) each with 4 stamens and 4 perianth leaves. The bracteoles α, β, β', β' are present. (See diagram.) All these leaves are united with one another. In the ♀ catkin only two, the lateral, flowers occur, and the same bracts. After fertilisation, the ovary gives a one-seeded nut, under which is found a 5-lobed scale, the product of subsequent growth of the 5 leaves. The flower is chalazogamic (see p. 81 and art. *Chalazogamae*).

Stem.
flr. flr. flr.
β' β'
α β
bract.

Alocasia Neck. Araceae (VI). 20 sp. E. Ind. Herbaceous. Monœcious. "*A. odora*, C. Koch, is supposed by Delpino to be fertilised by snails. The spadix is covered in its whole length with normal and abortive stamens and pistils; only ♀ flowers occur in the lower wider part of the spathe, and they only are mature in the first period. From this chamber an attractive odour issues, and the snails are admitted by a narrow entrance. In the second stage this entrance closes and the anthers dehisce. Snails which creep on to flowers in this stage seek vainly for the entrance, and dust themselves with pollen, which they carry to the stigmas of younger plants" (Müller).

Aloe Tourn. Liliaceae (III). About 85 sp., mostly in Cape Colony, and especially on the dry Karroo desert. The plant is usually of shrubby or arborescent habit, the stem growing in thickness and branching. The leaves are borne in dense rosettes at the ends of the branches, and are usually very fleshy, with thick epidermis and sometimes a waxy surface. From them the drug is obtained; they are cut across and the juice collected and evaporated to the necessary stiffness.

Alonsoa Ruiz et Pav. Scrophulariaceae (II. 3). 6 sp. S. Am.

Alopecurus Linn. Gramineae (VIII). 20 sp. temp. *A. pratensis* L. (fox-tail, a valuable pasture grass) and 3 others in Brit. Flr. protogynous.

Alphitonia Reissek. Rhamnaceae. 6 sp. New Cal., Austr., Moluc.

Alphonsea Hook. f. Anonaceae (I). 9 sp. trop. As.

Alpinia Linn. Zingiberaceae. 40 sp. trop. sub-trop. As., Austr., &c. The flr. has a small tubular calyx, a corolla with short tube and three large teeth, and a big labellum; the lateral staminodes are much reduced or wanting. Anther lobes divided by broad connective.

Alsine Scop. = Arenaria Linn.

Alsodeia Thou. (*Rinorea* Aubl.) Violaceae: 40 sp. trop.

Alsomitra M. Roem. Cucurbitaceae (I). 11 sp. Indo-mal., Austr., S. Am.

Alsophila Br. Cyatheaceae. About 70 sp. trop. They are mostly large tree ferns with naked sori (the only genus of C. with no indusium). The pith of some sp. is eaten by natives of Australia, &c.

Alstonia R. Br. Apocynaceae (I. 3). 30 sp. E. As., Austr., Polynes. Leaves in whorls. The bark has tonic properties.

Alstroemeria Linn. Amaryllidaceae (III). 40 sp. esp. S. Am. The leaves are twisted at the base so that the true upper surfaces face downwards (the internal structure is also reversed). The capsule splits explosively.

Alternanthera Forsk. Amarantaceae (4). 20 sp. Am., Austr.

Althaea (Tourn.) Linn. Malvaceae (II). 15 sp. temp. Old World. *A. officinalis* L. (marsh mallow) and *A. hirsuta* L. occur in Brit. *A. rosea* Cav. is the holly-hock.

Altingia Noronha. Hamamelidaceae. 2 sp. China to Java. Like Liquidambar. The male flrs. are reduced to naked sta., with basifixed anthers dehiscing laterally, so that only by comparison with related forms can it be shown that the spike of sta. is really an infl. and not a flr.

Alyssum Tourn. Cruciferae (IV. 17). 100 sp. Medit., Eur.

Amanoa Aubl. Euphorbiaceae (A. I. 1). 6 sp. trop. Am., Afr.

Amarantaceae. Dicotyledons (Archichl. Centrospermae). An order so closely allied to Chenopodiaceae, that it seems scarcely just to separate them. They differ chiefly in habit, the Am. not as a rule being halo- or xero-phytes, and having larger leaves, rarely succulent. The flrs. are in cymes in the axils of the leaves, so that the total infl. is generally racemose. The typical diagram is the same as that of the C. Perianth membranous. [For details, see *Nat. Pfl.*]

Classification and chief genera (after Schinz):

A. *AMARANTOIDEAE* (anther 4-locular).
 1. *Celosieae* (ovules > 1): Celosia.
 2. *Amaranteae* (ovule 1): Amaranthus.

B. *GOMPHRENOIDEAE* (anther 2-locular).
 3. *Guillemineae* (sta. perigynous): Guilleminea.
 4. *Gomphreneae* (sta. hypogynous): Gomphrena, Iresine.

Amaranthus Linn. Amarantaceae (2). 45 sp. trop. and temp. ("love-lies-bleeding"). The infl. is often made up of an enormous number of flrs., is very conspicuous, and probably insect-fertilised.

Amaryllidaceae. Monocotyledons (Liliiflorae). 75 gen. with about 700 sp. mostly trop. and sub-trop. They resemble Liliaceae in most respects but have an inferior ovary. Living, as they chiefly do, in dry climates, they are mostly xerophytes. Many are bulbous, leafing only in the wet season, others, *e.g.* Agave, &c., have fleshy leaves covered with wax. A few (§ III) have ordinary leafy stems; many have rhizomes. The infl. is usually borne on a scape and has the usual spathe seen in Monocotyledons. It is always cymose, but often umbel- or head-like in form by condensation of the flrs. Flr. ☿, regular or zygomorphic (transversely so in Anigozanthos). It has an inf. ovary of 3 cpls. with axile placentae and ∞ anatropous ovules, 6 sta. with introrse anthers, 6 petaloid perianth-segments, and in some cases (Narcissus and its allies) a corona, looking like an extra perianth whorl, between the normal perianth and the sta. Eichler looks on this as the combined ligular outgrowths of the perianth leaves, Pax (*Morphologie* p. 227 or *Nat. Pfl.*) as the stipules of the sta., giving a series of flrs. showing transitions from simple stipular outgrowths on each sta. to a full corona (Caliphruria, Sprekelia, Eucharis, Narcissus). The fruit is usually a capsule, sometimes a berry. [Placed in Epigynae by Benth.-Hooker.]

Classification and chief genera (after Pax):

I. *AMARYLLIDOIDEAE* (bulbous, scapigerous): Haemanthus, Galanthus, Amaryllis, Crinum, Eucharis, Narcissus.

II. *AGAVOIDEAE* (rhizome; leaves fleshy, in rosettes): Agave, Fourcroya.

III. *HYPOXIDOIDEAE* (rhizome; stem with small ordinary leaves): Alstroemeria, Bomarea, Anigozanthos.

IV. *CAMPYNEMATOIDEAE* (anthers extrorse): Campynema.

Amaryllis Linn. Amaryllidaceae (1). 1 sp. *A. belladonna* L., Cape Colony. The flr. is rendered zygomorphic by the upward curve of the sta.; the style projects above the anthers, favouring cross-pollination.

Amasonia Linn. Verbenaceae (II). 6 sp. trop. Am.

Ambora Juss. = Tambourissa Sonn.

Ambrosia Linn. Compositae (V). 15 sp., 1 Medit., 14 Am. Heads unisexual, the ♀ one-flowered. Fruit enclosed in the involucre.

Ambrosinia Linn. Araceae (VII). 1 sp. Medit.

Amelanchier Medic. Rosaceae (II. 4). 10 sp. N. temp.

Amellus Linn. Compositae (III). 9 sp. S. Afr.

Amentaceae = orders in cohorts 2, 3, 4, of Archichlamydeae.

Amethystea Linn. Labiatae (I. 1). 1 sp. Siberia.

Amherstia Wall. Leguminosae (II. 3). 1 sp., *A. nobilis* Wall. (India), remarkable for its splendid flrs. Stalk and bracts as well as petals are bright red. Sta. united in a tube.

Amianthium A. Gray = Zygadenus Michx.

Amicia H. B. et K. Leguminosae (III. 7). 5 sp. Andes. In *A. Zygomeris* DC. the big stipules protect the bud.

Ammannia (Houst.) Linn. Lythraceae. 18 sp., wet places, cosmop.

Ammi (Tourn.) Linn. Umbelliferae (5). 6 sp. Old World.

Ammobium R. Br. Compositae (IV). 2 sp. New S. Wales. *A. alatum* R. Br. is often cultivated for its flower-heads, which, when dried, form one of the many "everlastings."

Ammophila Host. Gramineae (VIII). 1 sp. N. temp. (incl. Brit.), *A.* (*Psamma*) *arundinacea* Host., common on sandy coasts (marram grass). It is largely used to bind sand dunes, possessing a long rhizome. After some years a light soil is formed in which fescue and other plants take root, and gradually the whole is covered with vegetation. The leaves curl up inwards in dry air, thus avoiding transpiration (see order). [See p. 186.]

Amomum Linn. Zingiberaceae. 50 sp. trop. As., Afr., Austr., Polynes. The leafy stems rarely bear flrs.; these are borne on other axes springing directly from the rhizome. Many sp. furnish forms of Cardamoms. See Elettaria.

Amorpha Linn. Leguminosae (III. 6). 10 sp. N. Am. *A. fruticosa* L. is common in shrubberies. The small flrs. are arranged in a dense spike. Wings and keel are absent, the standard only remaining; it folds round the stamen-tube at the base. The flr. is protogynous with persistent stigma.

Amorphophallus Blume. Araceae (IV). 15 sp. E. Ind. There is a corm-like rhizome, giving rise yearly to one enormous leaf (in some sp. the stalk 15 feet long and the leaf 10 feet across) and an equally gigantic infl. (in *A. Titanum* Becc. 3 feet high) with ♂ flrs. above and ♀ below. Its dirty red and yellow colour, and fœtid smell, attract numbers of carrion flies by which it is fertilised; they are often so deceived as to lay their eggs on the spadix.

Ampelidaceae (or Ampelideae) = Vitaceae.

Ampelodesma Beauv. Gramineae (X). 3 sp. Medit. and Afr. The leaves of *A. tenax* Link. (Algiers) are used like Esparto (Stipa).

Ampelopsis (Rich. in) Michx. = Vitis Linn. (*A. hederacea* DC. = V. hed.; *A. quinquefolia* Michx. = V. hed.; *A. Veitchii* Hort. = V. inconstans).

Amphicarpaea Ell. Leguminosae (III. 10). 15 sp. trop. and temp. N. Am., Japan, Himalaya. *A. monoica* Ell. and others have cleistogamic flrs. below, which give subterranean fruits like Arachis.

Amphicome Royle. Bignoniaceae (II). 2 sp. Himal.

Amsinckia Lehm. Boraginaceae (IV. 2). 8 sp. W. Am.

Amsonia Walt. Apocynaceae (I. 3). 7 sp. N. Am., Japan.

Amygdalus (Tourn.) Linn. = Prunus Tourn. (*A. communis* L. = P. Amygd. *A. Persica* L. = P. Pers.)

Amyris P.Br. Rutaceae (IX). 12 sp. trop. Am.

Anabasis Linn. Chenopodiaceae (10). 17 sp. Medit., As.

Anacampseros. Portulacaceae. 9 sp. S. Afr. Xerophytes with fleshy leaves; stipules represented by bundles of hairs protecting the young leaves in the bud.

Anacamptis Rich. = Orchis Linn.

Anacardiaceae. Dicotyledons (Archichl. Sapindales). 59 gen. with 500 sp., chiefly found in the tropics, but occurring also in the Medit., Chino-Jap., N. Amer., and Andine regions. In habit they resemble plants of other families, *e.g.* Rutaceae, Leguminosae, Sapindaceae, &c., but their floral characters mark them off as a distinct order. They are trees or shrubs with alt. exstip. leaves and panicles of flrs. Resin-passages occur, but the leaves are not gland-dotted (hence they cannot be confounded with Rutaceae).

The receptacle may be convex, flat or concave, and a gynophore or other axial outgrowth may occur. The flr. is typically 5-merous, but usually with reduction in the essential organs. The sta. are generally less than 10, the cpls. most commonly 3, rarely (3). Very often only one of the three is fertile, and frequently only one cpl. is found at all. Ovule solitary, anatropous with dorsal raphe. Fruit various. Endosperm. [Placed in Sapindales by B.-H.]

Classification and chief genera (after Engler):

A. 5 free cpls. or 1. Leaf simple, entire:

I. *MANGIFEREAE*: Mangifera, Anacardium.

B. Cpls. united. Lf. rarely simple:

II. *SPONDIEAE* (ovules in each cpl.): Spondias.

III. *RHOIDEAE* (one ovule only, ovary free): Pistacia, Rhus.

IV. *SEMECARPEAE* (do., ovary sunk in axis): Semecarpus.

C. Cpl. 1. ♀ flr. naked. Lf. simple, toothed:

V. *DOBINEEAE*: Dobinea (only genus).

Anacardium Linn. Anacardiaceae (I). 8 sp. trop. Am. *A. occidentale* L. is the Cashew-nut, largely cultivated. Its stem yields a gum. The flrs. are polygamous. Each has one cpl. which yields a kidney-shaped nut with a hard testa containing a black acrid juice. The nut is edible if the testa be carefully removed. Under it the axis of the flr. swells up into a large pear-like body, fleshy and edible, and so the seeds are distributed by animal agency.

Anacharis Rich. = Elodea Michx.

Anacyclus Linn. Compositae (VII). 12 sp. Medit.

Anagallis (Tourn.) Linn. Primulaceae (III). 12 sp. Eur., As., Afr., S. Am. 2 sp. in Brit., the pimpernels. *A. arvensis* L. is often called 'poor man's weather-glass,' because the flrs. close in dull or cold weather.

Anagyris Linn. Leguminosae (III. 2). 2 sp. Medit.

Anamirta Colebr. Menispermaceae. 7 sp. Malayan region. The achenes of *A. Cocculus* Wight et Arn. are known as "Cocculus indicus" and are sometimes used to adulterate porter, &c. though they contain an irritant poison. In the angles between the big veins of the leaves are acaro-domatia covered with hairs (see p. 115).

Ananas Tourn. Bromeliaceae (1). 6 sp. trop. Am.; of these the best known is *A. sativus* Schult., the Pine-apple. The stem is short (terrestrial) and leafy, bearing a terminal infl. of a mass of flrs. in the axils of bracts. These, together with the axis and the fruits, form a general fleshy mass after fertilisation, and the main axis usually goes on beyond it and produces more green leaves—the 'crown' of the pine-apple. Seeds are rarely formed. [See *Treas. of Bot.*]

Anaphalis DC. Compositae (IV). 30 sp. Eur., As.

Anastatica Linn. Cruciferae (IV. 18). 1 sp., *A. hierochuntina* L., the Rose of Jericho. This plant inhabits the regions from Syria to Algeria, where a long dry season occurs every year. While the seeds are ripening the leaves fall off and the branches fold inwards until the whole is reduced to a dry ball of wicker-work. In this state it is easily loosened from the dry ground and it *may* be blown bodily along by the wind, the fruits remaining closed. If it be driven into water or on to wet soil, or in any case when the wet season comes on, the hygroscopic nature of the twigs causes their unfolding, and at the same time the capsules open and shed their seeds. [See pp. 110, 168.]

Anaxagorea St Hil. Anonaceae (3). 20 sp. trop. As., Am.

Anchusa Linn. Boraginaceae (IV. 3). 40 sp. Old World. *A. officinalis* L. was formerly officinal and is widely scattered, occurring as an escape in Brit.

Ancistrocladaceae. Dicotyledons (Archichl. Parietales). Only genus Ancistrocladus (*q.v.*). The order is united with Dipterocarpaceae by Bentham and Hooker, but separated by Gilg (in *Nat. Pfl.* 1894), on the ground of the 1-locular ovary, endosperm, &c.

Ancistrocladus Wall. Ancistrocladaceae. 8 sp. trop. Afr., As. They are lianes, with sympodial stem-structure, each member ending in a tendril of a watch-spring pattern. Leaves alt., lanceolate, entire, with minute stipules. Racemose infl. of ☿ regular flowers. K 5 with unequal teeth; C (5) very slightly united, convolute; A 5 or 10. $\overline{G}$, 1-locular, with 1 basal erect semi-anat. ovule. Nut. Endosperm.

Andersonia R. Br. Epacridaceae. 20 sp. W. Austr. Incl. in Sprengelia in *Nat. Pfl.*

Andira Lam. (*Vouacapoua* Aubl.) Leguminosae (III. 8). 20 sp. trop. Am. *A. inermis* H. B. et K. is one of the 'rain-trees' (see Pithecolobium).

Andrachne Linn. Euphorbiaceae (A. I. 1). 8 sp. Medit., China, Cape Col., Am.

Androcymbium Willd. Liliaceae (1). 13 sp. Medit., S. Afr.

Andrographis Wall. Acanthaceae (IV. B). 20 sp. trop. As.

Andromeda Linn. Ericaceae (II. 4). 6 sp. boreal. *A. polifolia* L. in peat bogs in Brit.

Andropogon Linn. Gramineae (II). 180 sp. cosmop. *A. Schoenanthus* L. (trop. As., Afr.) is the Rusa grass of India; when distilled it yields an aromatic oil known as Rusa oil or geranium oil. A variety of it is the lemon grass, yielding lemon-grass oil. *A. Nardus* L. (trop. As., Afr., Austr., cult. in Ceylon) yields citronella-oil (for a full account see Semi-ann. Rep., Schimmel and Co., Oct. 1898). All are largely used in perfumery. *A. squarrosus* Linn. f. (*A. muricatus* Retz.) is the khus-khus of India, the roots of which are woven into fragrant mats, baskets, and fans, which give off scent when they are sprinkled with water. [*A. Sorghum* Brot. = *S. vulgare* Pers.]

Androsace (Tourn.) Linn. Primulaceae (1). 50 sp. N. temp., chiefly alpine. Tufted xerophytic plants, often heterostyled like Primula.

Androsaemum Tourn. = Hypericum Linn.

Andryala Linn. Compositae (XIII). 12 sp. Medit.

Aneilema R. Br. Commelinaceae. 60 sp. trop.

Aneimia Sw. Schizaeaceae. About 30 sp. trop. Am. The leaf divides at the base, in a way which has been compared with the behaviour of the fronds of Ophioglossaceae, into a sterile and a fertile portion. The two lowest pinnae form a pair of panicles bearing sori (*cf.* Osmunda), and resembling the infl. of many Spermaphyta.

Anemarrhena Bunge. Liliaceae (III). 1 sp. China.

Anemone Linn. Ranunculaceae (3). 90 sp. N. and S. temp. *A. nemorosa* L. (wood anemone) and *A. Pulsatilla* L. (Pasque flower) in Brit. Herbs with rhizomes and 'radical' leaves. Flrs. solitary or in cymes, apetalous; the involucre of green leaves in the common Hepatica (*A. Hepatica* L.) is so close to the flr. as to resemble a calyx. The flr. of the first named sp. contains no honey, is white, and visited for pollen by insects of low type; that of the third is blue and bee-visited, whilst in Pulsatilla there is honey secreted by staminodes and the long-tubed blue flr. is visited almost solely by bees. The achenes of many sp. have hairs aiding wind-dispersal.

Anemonopsis Sieb. et Zucc. Ranunculaceae (2). 1 sp. Japan.

Anemopaegma Mart. Bignoniaceae (1). 25 sp. Braz.

Anethum Tourn. = Peucedanum L.

Angadenia Miers. Apocynaceae (IV. 4). 20 sp. trop. Am.

Angelica (Riv.) Linn. Umbelliferae (6). 20 sp. N. temp. and N. Z. (p. 146). *A. sylvestris* L. in Brit. See Archangelica.

Angelonia Humb. et Bonpl. Scrophulariaceae (II. 3). 24 sp. trop. Am.

Angianthus Wendl. Compositae (IV). 22 sp. temp. Austr. Heads united into dense spikes or compound heads (*cf.* Echinops).

Angiopteris Hoffm. Marattiaceae (I). 1 sp. in many vars., *A. evecta* Hoffm., Madag., Indo-Mal. Large ferns with the sori not united into synangia as in most of the order. There is an annulus like that of Osmundaceae at the apex of the sporangium. The roots arise close to the apex and burrow downwards and outwards through the stem and the leaf-bases, emerging a good way down.

Angiospermae. One of the two great divisions of Phanerogams or Spermaphytes, distinguished from the Gymnosperms by the fact that the carpels are invariably so infolded or arranged as to form an ovary in which the ovules are borne. Further, the endosperm is formed after fertilisation, instead of before it as in G.

All A. possess true flowers, the essential parts of which are stamens and carpels. The former bear pollen sacs (= micro-sporangia of Pteridophyta, *q.v.*), the latter ovules (= mega-sporangia). [See Gymnosperms.] The pollen, in structure and development, closely resembles both the microspores of Pt. and the pollen of G.; but in the carpels we find important differences. The ovule is always enclosed in the carpel; it (*cf.* fig. 9, p. 81) has 2 integuments (or 1) and in the nucellus we find as a rule one embryo-sac (more in some Chalazogams, Loranthaceae, &c.), in which is one ovum, at the upper (micropylar) end, not enclosed in an archegonium. On either side of it is another naked cell; these two are usually regarded as abortive ova (*synergidae*). At the other end of the embryo-sac are 3 cells (*antipodal cells*), commonly supposed to represent another *egg-apparatus* (the name often given to the ovum and synergidae) which is now entirely abortive. In the centre of the sac is the large central nucleus, formed as described on p. 80. Fertilisation occurs on the arrival of the pollen-tube, one of the male nuclei in it fertilising the ovum, the other uniting with the central nucleus or sometimes with the upper nucleus before it has fused with the lower. The zygote now forms the embryo, the central nucleus the endosperm (p. 104). Opinions differ as to the homologies of the cells in the embryo-sac, but the most favoured view is that cells formed before fertilisation together represent a ♀ prothallus (*cf.* Pteridophyta, Gymnospermae, and p. 54), whose full development into a nutritive body for the embryo is delayed until the stimulus of union with the second male nucleus (*cf.* Gymnospermae).

The pollen-tube may enter by the micropyle or by the chalaza (p. 81 and *cf.* Chalazogamae).

Parthenogenesis, or development of the ovum into an embryo without fertilisation, occurs in Antennaria, Alchemilla, &c., embryo formation by adventitious budding in Alchornea, Funkia, &c., apogamy (*cf.* Filicineae) in Balanophora.

A. are divided into Mono- and Di-cotyledons (*q.v.* and see p. 125). See also Part I. and articles above quoted.

Angolaea Wedd. Podostemaceae. 1 sp. Angola.

Angophora Cav. Myrtaceae (II. 2). 4 sp. Austr.

Angraecum Bory (incl. *Macroplectrum* Pfitz.). Orchidaceae (31). About 25 sp. trop. Afr., Madag. &c. Epiphytes; monopodial. The most interesting sp. is *A. sesquipedale* Thou., the wax-flower. At the base of the labellum is an enormous spur, 12 to 14 inches long, at the bottom of which the honey is secreted. As Darwin observed (*Orchids*, p. 162, *q.v.*), this flr. must have a corresponding large insect, with a tongue of the same length, as its fertiliser. This idea was ridiculed at the time, but the moth has since been discovered. The flr. and moth afford an interesting example of mutual adaptation (*cf.* Yucca, Ficus, &c.).

Anguillaria R. Br. Liliaceae (I). 2 sp. Austr., Tasm.

Anguloa Ruiz et Pav. Orchidaceae (18). 3 sp. Andes; epiphytic.

Anguria (Tourn.) Linn. Cucurbitaceae (II). 17 sp. trop. Am.

Anhalonium Lem = Mammillaria Haw. (same spec. names). *A. Williamsii* Lem. = Echinocactus Williamsii.

Anigozanthos Labill. Amaryllidaceae (III). [Haemodoraceae Benth.-Hooker.] 10 sp. Austr. Flr. transversely zygomorphic (pp. 31, 73).

Anisacantha R. Br. (*Bassia* All. in *Nat. Pfl.*) Chenopodiaceae (5). 6 sp. Austr.

Anisacanthus Nees. Acanthaceae (IV. B.). 5 sp. Mex., Texas.

Anisadenia Wall. Linaceae. 2 sp. Himal.

Aniseia Choisy = Ipomœa Linn.

Anisochilus Wall. Labiatae (VII). 15 sp. trop. As., W. Afr.

Anisodus Link et Otto. = Scopola Jacq.

Anisomeles R. Br. Labiatae (VI. 4). 6 sp. Mauritius, Indo-Mal.

Anisophyllea R. Br. Rhizophoraceae. 5 sp. palaeotrop. It differs from other R. in its drupe fruit, exalbuminous seed, and alt. exstip. leaves, which are dimorphic in some sp.

Anisophyllum Haw. = Euphorbia Linn.

Anisoptera Korth. Dipterocarpaceae. 16 sp. Indo-Mal.

Anisotoma Fenzl. Asclepiadaceae (II. 4). 2 sp. S. Afr.

Anoda Cav. Malvaceae (II). About 16 sp. trop. Am.

Anodendron A.DC. Apocynaceae (II. 4). 7 sp. Ceylon to China.

Anœctochilus Blume. Orchidaceae (4). 8 sp. Indo-Mal.

Anogeissus Wall. Combretaceae. 4 sp. trop. Afr. and As.

Anoiganthus Baker. Amaryllidaceae (1). 1 sp. Natal.
Anomatheca Ker-Gawl. = Lapeirousia Pourr. (same spec. names).
Anona Linn. Anonaceae (6). 60 sp. trop. Am., Afr., As. Frt. compound, often very large, made up of the individual berries derived from the separate cpls., sunk in, and united with, the fleshy receptacle. That of some cult. sp. is edible, *e.g.* of *A. Cherimolia* Mill. (cherimoyer; trop. Am.), *A. squamosa* L. (sweet sop or sugar apple; E. Ind.), *A. muricata* L. (sour sop; trop. Am.) and *A. reticulata* L. (custard-apple or bullock's heart; trop. Am.).

A. rhizantha Eichl. (Braz.) gives off, near the ground, shoots which creep as rhizomes below the soil, bearing scale leaves only. The flrs. are borne on branches of these which come above the ground.

Anonaceae. Dicotyledons (Archichl. Ranales). 46 gen. 620 sp. chiefly trop. (esp. Old World). Trees and shrubs (exc. one sp.) with usually two-ranked undivided exstip. leaves. The stem is sometimes sympodial, at least in the infl. Oil passages are present.

Flrs. regular, ☿ (rarely unisex.), solitary or in infl. of various types. The usual formula is P $3 + 3 + 3$ (one or two outer whorls sepaloid); A∞ (rarely few), spiral, hypogynous; $\underline{G}\infty$ (exc. Monodora). Ovules usually ∞, ventral or basal, anatropous. Fruit commonly an aggregate of berries; where these are many-seeded they are frequently constricted between the seeds. In Anona, &c. the berries coalesce with the receptacle. Seeds with ruminate endosperm (the chief character that separates A. from Magnoliaceae). Many sp. yield valuable edible fruits, *e.g.* Anona, Artabotrys.

Classification and chief genera (after Prantl):

A. Perianth present; flr. hypogynous.

a. Apocarpous.

1. *Miliuseae* (sta. not broadened above anther): Miliusa.
2. *Uvarieae* (sta. broadened above anther; corolla imbricate): Uvaria, Asimina, Guatteria.
3. *Unoneae* (ditto but valvate; pets. usually spreading): Unona.
4. *Melodoreae* (as 3, but pets. erect, touching at edges): Oxymitra, Melodorum.
5. *Mitrephoreae* (as 3, but inner pets. stalked): Mitrephora.
6. *Xylopieae* (as 3, but pets. hollow at base, and constricted above it): Xylopia, Artabotrys, Anona.

b. Syncarpous; ov. uniloc. with parietal plac.

7. *Mondoreae:* Mondora (only genus).

B. No perianth; flr. perigynous.

8. *Eupomatieae:* Eupomatia (only genus).

[Placed in Ranales by Benth.-Hook., in Polycarpicae by Warming.]

Anopterus Labill. Saxifragaceae (V). 2 sp. Austr., Tasm.
Anotis DC. Rubiaceae (I. 2). 20 sp. Indo-Mal., 1 S. Am.
Anplectrum A. Gray. (*Diplectria* Rchb.) Melastomaceae (1). 17 sp. Malayan.

Ansellia Lindl. Orchidaceae (9). 4 sp. trop. Afr.

Antennaria Gaertn. Compositae (IV). 15 sp. extra-trop., exc. Afr. *A. dioica* Gaertn. (mountain everlasting or cat's foot) occurs in Brit. It is a small creeping diœcious perennial, hairy and semi-xerophytic. It is found chiefly on hills and at the sea-shore, but is not common in intermediate places (p. 186). In *A. alpina* (L.) R. Br. only ♀ plants usually occur, and these show true *parthenogenesis*, the ovum developing into an embryo without fertilisation (not to be confused with the vegetative budding of Alchornea).

Anthacanthus Nees. Acanthaceae (IV. B). 6 sp. W. Ind.

Anthemis Mich. ex Linn. Compositae (VII). 100 sp. Eur., Medit. (4 in Brit.—chamomile). The frt. of *A. arvensis* L. has papillae on its upper surface which become sticky when wetted (see Linum).

Anthephora Schreb. Gramineae (III). 5 sp. trop. Am., trop. and S. Afr.

Anthericum Linn. Liliaceae (III). 60 sp. Afr., Eur., Am.

Anthistiria Linn. f. Gramineae (II). 9 sp. palaeotrop. *A. vulgaris* Hack. (Kangaroo grass) covers large areas in Austr. and S. Afr.

Anthobolus R. Br. Santalaceae. 5 sp. Austr. Hypogynous.

Anthocephalus A. Rich. Rubiaceae (I. 6). 3 sp. Malayan.

Anthocercis Labill. Solanaceae (V). 20 sp. Austr.

Anthocleista Afzel. Loganiaceae. 5 sp. trop. Afr.

Antholyza Linn. Iridaceae (III). 20 sp. Afr.

Anthospermum Linn. Rubiaceae (II. 17). 25 sp. Afr., Madag.

Anthostema A. Juss. Euphorbiaceae (A. II. 8). 3 sp. trop. Afr. The flrs. are in a cyathium like that of Euphorbia, but the ♂, reduced as in E. to a single sta., has a perianth at the place where in E. there is only a joint. (See E.) The ♀ also has a perianth.

Anthoxanthum Linn. Gramineae (VII). 4 sp. N. temp. and Ind.; *A. odoratum* L. (sweet vernal grass) in Brit., common in pastures (? valuable). The stems contain large quantities of coumarin, to which the smell (so characteristic of newly mown hay) is due; it may be easily recognized by chewing a stalk. Flr. with 2 sta. only, protogynous. The awns of the fruit are hygroscopic.

Anthriscus Bernh. Umbelliferae (5). 10 sp. Eur., As., Afr., 2 in Brit.; *A. sylvestris* Hoffm. (chervil) is a very common weed. *A. Cerefolium* Hoffm. is the cult. chervil of France &c.

Anthurium Schott. Araceae (I). 300 sp. trop. Am. (see *Bot. Jahrb.*, XXV. p. 352). Most are sympodial herbs, with an accessory bud always formed beside the 'continuation' bud of the sympodium. Axillary shoot often 'adnate' to the main one (*cf.* Solanaceae &c.). Aerial roots are frequently formed at the base of the leaves. Some sp. live as epiphytes. Flrs. ☿, with perianth, protogynous, and visited by insects, arranged in a dense mass upon a spadix, at whose base is a flat usually brightly coloured spathe. The fruit is a berry and when ripe is forced out of the spadix and hangs by two threads formed from the perianth, so that it is easily obtained by birds, and thus distributed. In *A. longifolium* G. Don the root apex has been observed to develope into a shoot (Goebel; see p. 32).

Anthyllis Riv. Leguminosae (III. 4). 20 sp. Eur., N. Afr., W. Asia. (*A. vulneraria* L., lady's fingers or kidney-vetch, in Brit.). The floral mechanism resembles that of Lotus; the stigma only becomes receptive when rubbed.

Antiaris Lesch. Moraceae (II). 5 sp. E. Ind. *A. toxicaria* Lesch. is the famous Upas-tree of Java. The latex contains a virulent poison. Extraordinary stories of the effects of this were spread abroad about a century ago. The surroundings of the tree, within a radius of several miles, were said to be a total desert, the poisonous influence emanating from the tree being fatal to all other forms of life. The noxious volcanic valleys, containing quantities of carbon dioxide, are probably responsible for the origin of these legends (see *Treas. of Bot.*).

Anticlea Kunth. = Zygadenus Michx. (same spec. names).

Antidesma Burm. Euphorbiaceae (A. I. 1). 70 sp. Old World trop.

Antigonon Endl. Polygonaceae (III. 5). 4 sp. trop. Am. *A. Leptopus* Hook. et Arn. is a (stem) tendril climber.

Antirrhinum Tourn. Scrophulariaceae (II. 5). 32 sp. N. Hemisph. *A. majus* L. the snapdragon, is found wild in some parts of Brit., but is probably an escape from cultivation. The mouth of the flr. is closed and the honey is thus preserved for bees, which alone are strong enough to force an entrance.

Anychia Michx. Caryophyllaceae (II. 4). 2 sp. N. Am.

Aotus Sm. Leguminosae (III. 2). 11 sp. Austr., Tasm.

Apera Adans. Gramineae (VIII). 2 sp. Eur., W. As. *A.* (*Agrostis*) *Spica-Venti*, Beauv., the silky bent-grass, in Brit.

Apetalae = Monochlamydeae or Incompletae (see p. 135).

Aphelandra R. Br. Acanthaceae (IV. B). 60 sp. trop. Am. Several are cultivated for their showy flrs. and coloured bracts.

Aphyllanthes Tourn. Liliaceae (III). 1 sp. Medit., *A. monspeliensis* L. The solitary flr. is surrounded by an involucre of bracts, and is regarded as the only remaining flr. of a head; the other flrs. are only represented by their bracts (Engler).

Apicra Willd. Liliaceae (III). 7 sp. S. Afr. Xerophytes, nearly related to Aloe and Gasteria. Some, *e.g. A. foliolosa* Willd., show an extreme superposition of leaves, and form almost solid masses of fleshy tissue, biologically though not morphologically equivalent to a cactus.

Apios Moench. Leguminosae (III. 10). 5 sp. N. Am., China. *A. tuberosa* Moench. is a favourite climber, a perennial with tuberous base to the stem. The flowers are peculiar, the keel forming a tube which bends up and rests against a depression in the standard. When liberated by insects or otherwise the tension of the keel makes it spring downwards, coiling up more closely. This causes the essential organs to emerge at its apex.

Apium (Tourn.) Linn. (incl. *Helosciadium* Koch). Umbelliferae (5).

14 sp. cosmop. 3 in Brit. of which *A. graveolens* L., found in marshy places near the coast, is the celery. The wild plant is poisonous, but cultivation and the blanching (etiolation) of the leafstalks by heaping earth over them, renders the garden form innocuous. The two other sp. are common in ditches.

Aplopappus Cass. (*Haplopappus* Endl.). Compositae (111). 100 sp. W. Am.

Apocarpae (Benth.-Hooker). The 6th series of Monocotyledons (p. 136).

Apocynaceae. Dicotyledons (Sympet. Contortae). 130 gen. and abt. 1000 sp., mostly trop. A few are temp.; *Vinca minor* gives the N. limit in Eur. Erect plants are rare, the order consisting mainly of twining shrubs; in the tropics many grow to large lianes. The stem has bi-collateral bundles; latex is always present. The leaves are simple, usually opp., entire, rarely with small interpetiolar stipules. The primary type of infl. is a panicle, but in its later branchings it sometimes goes over into a dichasial cyme or a cincinnus. Bracts and bracteoles are both present.

Flr. ☿, regular, 5- or 4-merous. K (5), deeply lobed, quincuncial with odd sepal posterior; C (5), usually salver- or funnel-shaped, often hairy within, convolute (valvate in a few rare gen.); A 5, alternate with pets., epipetalous, with short included filaments; anther lobes full of pollen to the base, or empty at base and prolonged into rigid spines. Disc usually present. Cpls. (2) or 2 (united by style) or more, superior, 1- or 2-locular when syncarpous. Ovules ∞, anatropous, pendulous. Style usually simple with thickened head. Fruit a berry, or more often 2 follicles. Seeds usually flat and often with a crown of hairs serving for wind distribution. Endosperm or none; embryo straight.

In the common A. with a large stylar head the stigma is at the edge or under surface of the head and self-fertilisation is almost impossible. A very interesting mechanism is found in *Apocynum androsaemifolium*.

Classification and chief genera (after K. Schumann):

I. *PLUMIEROIDEAE* (sta. free or only loosely joined to stylar head; thecae full of pollen, rarely with spines; seeds usually without hairs):

1. *Arduineae* (syncarpous; style not split at base): Arduina, Allamanda, Landolphia.
2. *Pleiocarpeae* (apocarpous; style split at base; more than 2 cpls.): Pleiocarpa.
3. *Plumiereae* (ditto; 2 cpls.): Plumiera, Amsonia, Vinca, Tabernaemontana, Cerbera.

II. *ECHITOIDEAE* (sta. firmly joined to stylar head; thecae empty at base, and with spines; seeds hairy):

4. *Echitideae* (anthers included): Apocynum, Nerium, Strophanthus, Dipladenia.

5. *Parsonsieae* (anthers excluded): Parsonsia, Lyonsia.

[Placed in Gentianales by B. and H.; Contortae by Warming.]

Apocynum (Tourn.) Linn. Apocynaceae (II. 4). 3 sp. Eur., As., N. Am. Of these the most interesting is *A. androsaemifolium* L., a shrub often found in gardens under the name "American fly-trap," given to it because large numbers of flies are caught by the flrs. The mechanism resembles that of Asclepiadaceae. The ovary is crowned by a disc, stigmatic on the lower side and surrounded by the rigid lignified stamens. Honey is secreted at the base of the stamens and an insect in withdrawing its proboscis usually brings it up the narrow slit between two stamens. At the base of this is a drop of cement and higher up the anthers dehisce laterally; thus the insect withdraws the pollen on its proboscis, but considerable strength is required and small insects are usually held fast. On a second visit the pollen is scraped off upon the stigmatic surface. The seeds are crowned with hairs for wind carriage.

Aponogeton Linn. f. Aponogetonaceae. 15 sp. Afr., Madag., As., Austr. Water-plants with sympodial tuberous rhizomes. Leaves usually floating, but submerged ones occur in some sp., *e.g. A.* (*Ouvirandra*) *fenestrale* Hook. f. Here the whole tissue of the leaf between the veins breaks up as the leaf grows, leaving a network of veins with holes between them. Close round the veins is a little green tissue serving assimilatory purposes. The interior tissue does not contain the intercellular spaces characteristic of most water-plants, and Goebel (*Pflanzenbiol. Schild.* II. p. 319) suggests that this is because the holes in the leaf render all parts of it easily accessible to the water with its dissolved gases. Young leaves in the bud show no trace of this phenomenon. [See p. 160.]

The flrs. project above the water, and are arranged in spikes; the spathe is early thrown off. Some sp. have a perianth of 3 leaves, but usually it is of only 2 leaves or even 1, as in the Cape pond-weed (*A. distachyum* Thunb.) now so much cultivated for its sweet-scented flrs. The one leaf is attached to the axis of the spike by a broad base and looks like a bract. In this sp. the sta. are ∞ and cpls. 3—6, but in most we find A 3+3, G 3. Ovules 2 or ∞ in each, anatropous, erect. Fruit leathery. Embryo straight.

Aponogetonaceae. Monocotyledons (Helobieae). Only genus Aponogeton (*q.v.*). They are distinguished from Potamogetonaceae by the coloured perianth and straight embryo, from Juncaginaceae by the perianth and the sympodial structure. Benth.-Hooker place them in Naiadaceae with several other orders here treated separately.

Apostasia Blume. Orchidaceae (I). 4 sp. E. Ind. to Austr. Flr. almost regular, diandrous; ovary 3-locular.

Aquifoliaceae Dicotyledons (Archichl. Sapindales). 5 gen. 180 sp. chiefly Amer. Shrubs and trees with leathery alt. leaves and minute stipules. Infl. cymose. Flr. regular, unisexual, 3—6-merous with no disc. Usual formula K 4, C 4, A 4, $\underline{G}$ (4), 4-locular, with 1 or 2 pendulous anatropous ovules in each. Drupe. Endosperm. *Chief genus:* Ilex. [A. = Ilicineae B. and H. (coh. Olacales); placed in Frangulinae by Warming.]

Aquilegia (Tourn.) Linn. Ranunculaceae (2). 50 sp. N. temp. (*A. vulgaris* L., the columbine, in Brit.). The petals are prolonged into long spurs (cf. Delphinium), secreting honey that is only accessible to long-tongued insects. Sta. often 50 or more, in whorls of 5. Flr. protandrous, fertilised by humble-bees.

Arabis Linn. Cruciferae (IV. 15). 100 sp. N. temp., S. Am. 5 Brit. (rock-cress).

Araceae (= *Aroideae* Benth.-Hooker). Monocotyledons (Spathiflorae). 105 gen. with abt. 1000 sp. trop. and temp. but chiefly trop. (92 °/₀). Many types of vegetative habit occur in the order—herbs large and small, with aerial stems, tubers or rhizomes, climbing shrubs, climbing epiphytes, marsh plants, one water plant (Pistia) &c. In a few Pothoideae (the oldest group) the stem is monopodial, but in most A. it is sympodial. Each joint of the sympodium begins as a rule with one or more scale leaves before bearing foliage leaves. Accessory (collateral) buds are often found in the leaf axils. Sometimes, as in Anthurium, Philodendron &c., the axillary shoot is 'adnate' to the main axis for some distance (cf. Solanaceae, Zostera &c.). The buds usually appear in the leaf axils, but often get pushed to one side, and sometimes (*e.g.* Pothos) break through the leaf-bases as in Equisetum.

The leaves show many types. Pinnately and palmately divided leaves are frequent, but their development is not like that of such leaves in Dicotyledons. Holes are present in the leaves of Monstera. See *Nat. Pfl.* for details, and genera Monstera, Rhaphidophora, Philodendron, Helicodiceros, Dracontium, Zamioculcas &c.

The roots are adventitious and mostly formed above ground in the larger forms. Two types of aerial root occur—climbing roots and absorbent roots. The former, like those of ivy, are insensitive to gravity but show great negative heliotropism; they consequently cling closely to the support and force their way into all the crevices of its structure. The latter are insensitive to light, but respond markedly to gravity; they therefore grow down to the soil and enter it, branching out below ground and taking up nourishment.

The larger tropical A. show interesting stages in the development of epiphytism (see p. 173). The climbing forms grow to considerable size and form longer and longer aerial roots as they grow upwards. The original roots at the base of the stem thus become of less and less importance and it not uncommonly happens that they die away together with the lower end of the stem, so that the plant thus becomes an epiphyte. Of course, as it still obtains its water &c. from the soil, it is not an epiphyte in the sense that *e.g.* many

Orchids or Bromeliaceae are such, and it is evident that if this method of becoming epiphytic were the only one found in the order, these plants could with no more justice be classed as true epiphytes than the ivy which may often be seen in the 'bowls' of pollard willows in Europe (see p. 174), and which has got there by climbing up the trunk and dying away below. It is found however that some sp. of Philodendron, Pothos &c. are able to *commence* life as epiphytes. The fleshy fruit is eaten by birds and the seed dropped on a lofty branch. The seedling forms clasping roots and dangling aerial roots which grow steadily down to the soil, even if it be 100 feet or more away. It is hardly possible to suppose that these true epiphytic sp. have been evolved in any other way than from former climbing sp. The leaves of *Philodendron cannifolium* Schott have swollen petioles full of large intercellular spaces lined with mucilage. When rain falls these become filled with water and act as storage reservoirs. Lastly, some sp. of Anthurium &c. are true epiphytes without any connection with the soil (*e.g. A. Hügelii* Schott = *A. Hookeri* Kunth.); they have clasping roots, and also absorbent roots which ramify amongst the humus collected by the plant itself. The aerial roots of some Araceae possess a velamen like that of Orchids. [For further details see p. 173, and Schimper's *Epiph. Veg. Amerikas.*]

The flrs. are without bracts and are usually massed together on a cylindrical spadix enclosed in a large spathe; the spadix usually terminates a joint of the sympodium (the 'continuation' bud is generally in the axil of the leaf next but one before the spathe), so that there is only one formed each year. Flr. ☿ or monœcious (diœcious in Arisaema), with or without a perianth. Sta. typically 6 but usually fewer (down to 1), often united into a *synandrium* (*e.g.* Colocasia, Spathicarpa); in Ariopsis the synandria are again united to one another. Staminodes are often present, and these also may be fused into a synandrodium as in Colocasia. The gynœceum shows almost every possible variety of structure; it is frequently reduced to 1 cpl. Fruit a berry. The outer integument of the seed is often fleshy. Endosperm or none.

The flrs. are usually protogynous (even when monœcious). In many genera (incl. most in Eur.) the smell is disagreeable and attracts carrion flies as pollen carriers (see Arum, Dracunculus, Helicodiceros &c.).

Many A. contain latex, which is usually poisonous but is dispelled by heat. The rhizomes of many sp. contain much starch and are used as food (Caladium, Colocasia, Arum &c.).

Classification and chief genera (after Engler):

The grouping of the A. is very difficult and account has to be taken of histological as well as external characters.

I. *POTHOIDEAE* (land plts.; no latex or raphides; leaves

2-ranked or spiral; lateral veins of 2nd and 3rd order netted; flrs. usually ☿): Pothos, Anthurium, Acorus.

II. *MONSTEROIDEAE* (land plts.; no latex; raphides; lat. veins of 3rd, 4th, and sometimes 2nd orders netted; flr. ☿, usually naked; ovule anatrop. or amphitrop.): Rhaphidophora, Monstera, Spathiphyllum.

III. *CALLOIDEAE* (land or marsh plts.; latex; flr. usually ☿; ovule anatrop. or orthotrop.; lf. never sagittate, usually net-veined): Symplocarpus, Calla.

IV. *LASIOIDEAE* (land or marsh plts.; latex; flr. ☿ or ♂ ♀; ovule anatrop.; seed usually exalbum.; lf. sagittate, often much lobed, net-veined): Dracontium, Amorphophallus.

V. *PHILODENDROIDEAE* (land or marsh plts.; latex; flr. naked, unisex.; ovule anatrop. or orthotrop.; seed usually album.; lf. usually ||-veined): Philodendron, Zantedeschia.

VI. *COLOCASIOIDEAE* (land or marsh plts.; latex; flr. naked unisex.; sta. in synandria; ovule orthotrop. or anatrop.; seed album. or not; lf. net-veined): Remusatia, Colocasia.

VII. *AROIDEAE* (land or marsh plts.; latex; flr. unisex., usually naked; sta. free or in synandria; ovule anatrop. or orthotrop.; seed album.; leaves various, net-veined; stems mostly tuberous): Spathicarpa, Arum, Dracunculus, Helicodiceros, Arisaema.

VIII. *PISTIOIDEAE* (swimming plts.; no latex; flr. unisex., naked; ♂ flrs. in a whorl, ♀ solitary): Pistia (only genus).

Engler gives a genealogical tree of these groups, showing also their relation to Lemnaceae, thus

Monsteroideae
↑
Pothoideae → { Calloideae → Philodendroideae.
Lasioideae.
Aroideae → Pistioideae..... LEMNACEAE.
↓
Colocasioideae.

For further details of this most interesting order, see the account in *Nat. Pfl.* (by Engler), from which much of the above is abridged.

[Placed in Spadiciflorae (Eichl. Warm.), Nudiflorae (B. & H.).]

Arachis Linn. Leguminosae (III. 7). 7 sp. Braz. *A. hypogaea* L. is the earth-, ground-, or pea-nut, largely cultivated in warm regions for its seeds, which are edible and which when pressed yield one of the many oils used in place of, or to adulterate, olive oil. The flr. after fertilisation bends downwards (cf. Linaria) and the elongation of its stalk forces the young pod under ground, where it ripens.

Aralia Tourn. Araliaceae. 30 sp. N. Hemisph. The root of *A. Ginseng* Baill. (*A. quinquefolia* auct.) is the source of the famous Chinese medicine Ginseng. It is much valued in China as a tonic and stimulant, but is said to be devoid of medicinal value. For *A. papyrifera* Hook. see Fatsia.

Araliaceae. Dicotyledons (Archichl. Umbelliflorae). 51 gen. 400 sp. mostly trop., the chief centres being the Indo-mal. region and trop. Am. Mostly trees and shrubs; some are almost like palms in habit (p. 155). Many twine, others (*e.g.* Hedera) climb by aid of roots. Leaves usually alt., often large and compound, with small stipules. Flrs. small, in umbels which are frequently massed into large compound infls. Flr. ☿, regular, epigynous, usually 5 (3-∞)-merous. K 5, very small; C 5; A 5; $\overline{G}$(5), 5-locular, with 1 anatrop. pendulous ovule in each, the micropyle facing outwards. Styles free or united. Fruit usually a drupe with as many stones as cpls. Embryo small in rich endosperm. *Chief genera:* Fatsia, Hedera, Aralia, Panax.

[Placed in Umbelliflorae (Eichl. Warm.), Umbellales (B. and H.)]

Araucaria Juss. Coniferae (Arauc. 1 b; see C. for genus characters). 10 sp. S. Am., Austr., divided into 2 sections. To § 1, *Colymbea* (leaves broad, fruiting cpls. not winged), belongs *A. imbricata* Pav. (Chili), the monkey-puzzle of our shrubberies. Its seeds are edible and the wood is useful. *A. Bidwilli* Hook. (Austr.), the Bunya-Bunya pine, also belongs to this section. To § 2, *Eutacta* (needle leaves, scales winged), belong *A. excelsa* R. Br., the Norfolk I. pine, and others.

Araucariaceae. An order of Coniferae (*q. v.*).

Araujia Brot. Asclepiadaceae (II. 2). 10 sp. S. Am.

Arbutus (Tourn.) Linn. Ericaceae (II. 6). 20 sp. Medit., Orient., N. Am. *A. Unedo* L., the strawberry tree, is abundant at Killarney. The frt. (a dry berry) resembles a strawberry at a distance. It ripens in the second year, so that flr. and frt. occur together on a tree.

Arceuthobium Bieb. Loranthaceae (2). 9 sp. N. temp. See *Nat. Pfl.* and Johnson in *Ann. of Bot.* II., p. 137.

Archangelica Hoffm. Umbelliferae (6). 7 sp. N. temp. The petioles of *A. officinalis* Hoffm. are used in confectionery (angelica).

Archegoniatae. A term used to designate that division of the Veg. Kingdom in which the ♀ cell (ovum) is contained in an *archegonium*, *i.e.* a flask-shaped organ with a neck formed of one layer of cells. It includes the Bryophyta and Pteridophyta.

Archichlamydeae. One of the two primary divisions of Dicotyledons (p. 127).

Archontophoenix H. Wendl. et Drude. Palmae (IV. 6). 3 sp. E. Austr.

Arctium Linn. Compositae (XI). 1 sp., *A. Lappa* L., the burdock, often split into 4 sp., Eur. (incl. Brit.), As. The involucral bracts become hooked and woody after the flrs. wither, and aid in seed distribution. They adhere to the fur or clothes, but are soon torn from their hold and the plant springs back again without parting from them, jerking out the fruits.

Arctostaphylos Adans. Ericaceae (II. 6). 18 sp. chiefly N. Am. Two are circumpolar and occur in Brit. (alpine). *A. Uva-ursi* Spreng., the red bearberry, is common in the Highlands, especially on wind-swept ridges and dry places. *A. alpina* Spreng., the black bearberry, is rarer. The former is evergreen, the latter not. On this account and because of its soft berry it is sometimes placed in a separate genus *Arctous* Niedz. The berries form one of the principal foods of grouse &c. The flrs. appear as soon as the snow melts; they resemble those of Erica in structure and mechanism.

Arctotis Linn. Compositae (X). 58 sp. Afr., Austr.

Arctous Niedz. See Arctostaphylos.

Ardisia Sw. Myrsinaceae (II). 200 sp. Some show 'vivipary' like Rhizophora (*q. v.*).

Arduina Mill. = Carissa Linn.

Areca Linn. Palmae (IV. 6). About 15 sp. Malacca to New Guinea. *A. Catechu* L. is largely cultivated in trop. As. for its seeds (Areca or Betel nuts). The infl. is below the oldest living leaves, monœcious, with the ♀ flrs. at the bases of the twigs, the ♂ above. The seed is about as big as a damson; it is cut into slices and rolled up in a leaf of Betel pepper (*Piper Betle*) with a little lime. When chewed, it turns the saliva bright red; it acts as a stimulus upon the digestive organs, and is supposed by the natives (who use it habitually) to be a preventive of dysentery. For *A. oleracea* Jacq. see Oreodoxa.

Arenaria Linn. (incl. *Alsine* Scop., *Cherleria* Hall., *Honckenya* Ehrh., *Moehringia* L.). About 150 sp. cosmop. 8 in Brit. (sandworts), of which the most noteworthy is *A.* (*Honck.*) *peploides* L. the sea-purslane, common on sandy coasts. It has long creeping stems below the sand, bearing scale leaves; the green leaves are fleshy with water storage tissue (p. 186). *A. Cherleria* Hook. (*C. sedoides* L.), the cyphel, is a tufted alpine plant (p. 183) common in the Highlands.

Arenga Labill. Palmae (IV. 6). About 8 sp. E. Ind. Like Caryota, but the spadix unisexual. Sta. ∞, cpls. 3. *A. saccharifera* Labill., the Gomuti palm, is largely cultivated as a source of palm sugar (jaggery), obtained by evaporation of the sap that flows from wounds made in the young infl. The tree only flowers once. A variety of sago is obtained by washing and granulating the pith.

Arethusa Gronov. Orchidaceae (4). 2 sp. Japan and N. Am.

Aretia Hall. Merged in Androsace L. (12 sp. Eur., Siber.).

Argania Roem. et Schult. Sapotaceae (I). 1 sp. *A. Sideroxylon* R. & S., in Morocco. The fruit is eaten by cattle; the pressed seeds yield Argan oil, used instead of olive oil.

Argemone Tourn. Papaveraceae (II). 6 sp. trop. Am.

Argyreia Lour. Convolvulaceae (I. 4). 25 sp. trop. As., Afr.

Argyrolobium Eckl. et Zeyh. Leguminosae (III. 3). 40 sp. Afr., Medit., Ind. Mostly xerophytes.

Ariopsis J. Grah. Araceae (VI). 1 sp. E. Ind., *A. peltata* J. G., a small tuberous herb with hood-like spathes whose openings face downwards so that the flrs. are protected from rain &c. The few ♀ flrs. are at the base of the spadix, the ♂ above. This part is full of round holes leading into pear-shaped cavities surrounded each by a synandrium of 6-8 sta. The synandria are fused to each other so that the surface of the spadix is continuous from the opening of one flr. to that of the next.

Arisaema Mart. Araceae (VII). 50 sp. As., Abyss., N. Am. Like Arum, but diœcious. It is said to be fertilised by snails (cf. Alocasia).

Arisarum (Tourn.) Targ. Araceae (VII). 3 sp. Medit.

Aristea Soland. Iridaceae (II). 14 sp. S. Afr., Madag.

Aristida Linn. Gramineae (VIII). 100 sp. temp. and sub-trop.

Aristolochia Tourn. Aristolochiaceae. 180 sp. trop. and temp. They are herbs with rhizomes, or twining lianes. Of the latter *A. Gigas* Lindl., the pelican flower, is often grown in hot-houses for the sake of its enormous flrs. Many trop. sp. have a small leaf surrounding the stem at the base of each ordinary leaf, and looking like a stipule. This is really the first leaf of the axillary shoot, which grows very rapidly at first. In other cases this leaf remains small and its shoot does not develope, so that it looks like an interpetiolar stipule. In most sp. several buds are formed in each leaf axil; the flrs. usually come from the upper ones.

A. Clematitis L. (birthwort) occurs as an escape in Brit. The perianth is tubular, hooded at top, and enlarged below round the gynostemium; this has 6 sessile extrorse anthers below and as many stigmatic lobes above (these are really not the true stigmas, but the connectives of the anthers, which have assumed stigmatic functions). The young flr. stands erect and the perianth-tube contains numerous hairs, which are jointed at the base in such a way that they can easily be bent downwards but not upwards. There is no honey. Small flies enter the flr. at this stage and find the stigmas ripe, so that if they bear pollen from other flrs. fertilisation takes place. They are unable to escape until in the course of a day or two the pollen is shed, and then the hairs wither, the flr. at the same time bending downwards (cf. Arum). In *A. Sipho* L'Hérit. (Dutchman's pipe) the perianth is bent like a siphon and has a polished interior surface. The mechanism of all A. wants further investigation. It seems probable that there is a large amount of self-fertilisation.

Aristolochiaceae. Dicotyledons (Archichl. Aristolochiales). 5 gen. with 200 sp., trop. and warm temp., except Austr. Herbs or shrubs, in the latter case usually twining lianes. Leaves alt., stalked, often cordate, usually simple, exstipulate. Flr. ☿, epigynous, regular or zygomorphic. P. usually (3), petaloid. Sta. 6—36, free, or united with the style into a gynostemium (cf. Asclepiads, Orchids &c.).

Ovary 4—6-loc.; ovules ∞ in each loc., anatropous, horizontal or pendulous. Capsule. Embryo small in rich endosperm. The A. are difficult to place in the natural system. They have been put near Dioscoreaceae, though they are not monocotyledonous. Benth.-Hooker place them in Multiovulatae Terrestres, Eichler (Warming) in Hysterophyta. *Chief genera:* Asarum, Aristolochia.

Aristolochiales. The 8th cohort of Dicot. Archichl. (see p. 127).

Aristotelia L'Hérit. Elaeocarpaceae. 10 sp. S. temp.

Armeria Linn. Plumbaginaceae. 50 sp. N. temp. and andine. *A. vulgaris* Willd., the thrift or sea pink, is common on the coast of Brit. and in high mountain regions of Scotland (see p. 187). The primary root is perennial; each year's shoot dies down all but a short piece, on which the following year's shoot arises as an axillary branch. The infl. is a capitulum of cincinni, surrounded by a whorl of bracts, the outer ones forming a sheath round the top of the peduncle. After fertilisation the calyx becomes a membranous funnel-like organ aiding seed-distribution by wind.

Arnebia Forsk. Boraginaceae (IV. 4). 12 sp. Medit., Himal. Some have black spots on the corolla, which fade out as it grows older (see order, and cf. Diervilla, Fumaria &c.).

Arnica Rupp. Compositae (VIII). 18 sp. N. temp. and arctic.

Arnoseris Gaertn. Compositae (XIII). 1 sp., *A. pusilla* Gaertn., in Eur. (incl. Brit.). The bases of the involucral bracts enclose the ripe fruits (cf. Rhagadiolus).

Aroideae (Benth.-Hook.) = Araceae.

Arrhenatherum Beauv. Gramineae (IX). 3 sp. Eur., Medit. *A. avenaceum* Beauv., the false oat-grass or French rye-grass, in Brit.

Artabotrys R. Br. Anonaceae (6). 23 sp. Old World trop. They are cultivated for their sweetly scented flrs. and edible fruit. They usually climb by aid of recurved hooks, which are modified inflorescence-axes.

Artanthe Miq. = Piper Linn. (usually same spec. names; *A. elongata* Miq. = P. angustifolium).

Artemisia Linn. Compositae (VII). 200 sp. N. Hemisph., very common on the arid soil of the western U.S., the Steppes &c. 4 in Brit. (wormwood). Flr.-heads small, inconspicuous, and *wind* fertilised (cf. Poterium, Rheum and Rumex, Plantago, Thalictrum, &c.). In *A. vulgaris* L. the marginal florets are ♀, the rest ☿. The head is pendulous; the anther-tube projects beyond the corolla, so that the dry powdery pollen is exposed to the wind. On the tips of the anthers are long bristles which together form a temporary pollen-holder. Afterwards the style emerges and the large hairy stigmas spread out. The flr. affords a very interesting case of reacquisition of a character not found in most higher flowering plants.

Arthraxon Beauv. Gramineae (II). 9 sp. trop. Old World.

Arthropodium R. Br. Liliaceae (III). 8 sp. Austr., N.Z., New Caled.

Arthrotaxis Endl. = Athrotaxis D. Don.

Artocarpus Forst. Moraceae (II). 40 sp. Ceylon to China and Malay Arch. Many sp. show good bud-protection (p. 157) by the stipules. *A. laciniata* Hort. has large drip-tips (p. 143 and art. *Ficus*). Flrs. monœcious, the ♂ in pseudo-catkins, the ♀ in pseudo-heads. A multiple fruit is formed, the achenes being surrounded by the fleshy perianth and the common receptacle also becoming fleshy. The fruit contains much starch &c. and is a valuable food-stuff. Several sp. are cultivated all over the Trop., *e.g. A. incisa* L. (Bread-fruit tree) and *A. integrifolia* L. (Jack tree). The flesh has the texture of bread and is roasted before being eaten. The best cultivated forms (cf. pear, banana &c.) produce no seeds.

Arum (Tourn.) Linn. Araceae (VII). 15 sp. Eur., Medit. *A. maculatum* L. (cuckoo-pint, wake-robin, or lords and ladies) in Brit. It is a perennial, tuberous plant with monœcious flrs.; ♀ flrs. at base of spadix (each of 1 cpl., naked) and ♂ above (each of 2—4 sta.), and above these again rudimentary ♂ flrs. represented by hairs which project outwards and close the mouth of the spathe. The fœtid smell attracts small flies, which enter the spathe, find the stigmas ripe, and are kept prisoners till the pollen is shed; then the hairs wither and escape is possible (cf. Aristolochia). Fruit a berry. The starch of the tubers was formerly used as food under the name Portland arrowroot, but it is very difficult to get rid of the poisonous juices accompanying it. Other species are similarly used in Eur.

Arundinaria Michx. Gramineae (XIII). 25 sp. As., Am. Like Bambusa.

Arundo Tourn. Gramineae (X). 3 sp. trop. and temp. For *A. Phragmites* L. (Brit.) see P. communis. The stems of *A. Donax* L. are used for sticks, fishing-rods &c.

Asarum (Tourn.) Linn. Aristolochiaceae. 13 sp. N. temp. *A. europaeum* L., the asarabacca, is wild in Brit., but only as an escape from cultivation, it having been formerly medicinal. There is a rhizome below ground and creeping shoots above; the latter are sympodial, each annual joint bearing several scale leaves below, then two green leaves and a terminal flr. Flr. regular; P (3), sometimes with 3 small teeth between the segments (perhaps remnants of a former inner whorl); A 12; G (6). The dark-brown, resinously scented flr. is visited by flies, and is very protogynous; when the stigmas are ripe the sta. are all bent away, but later on they move up to the centre and dehisce extrorsely. The perianth lobes are bent in at first towards the centre of the flr. and form a sort of prison of it, but afterwards gradually straighten themselves. Müller regards the flr. as representing a stage in the development of the Aristolochia prison.

Asclepiadaceae. Dicotyledons (Sympet. Contortae). 218 genera with over 1300 sp. They are mostly confined to the Tropics (esp. Afr.), but there are a few in temp. regions. In vegetative habit they resemble Apocynaceae; some are perennial herbs, but the most are climbing shrubs or lianes, with simple, entire, opposite, exstipulate leaves. Latex is present. A large number, especially of the S. Afr. sp., are xerophytic; some, *e.g.* Periploca, with much reduced leaves, others, *e.g.* Hoya, and still more, Stapelia, with fleshy stems. Epiphytes also occur, of which the most interesting is Dischidia.

The infl. usually includes many flrs. and may be cymose or racemose (raceme or umbel). In the former case it is a dichasium, but as in Caryophyllaceae the one branch tends to outgrow the other, and a monochasial (cincinnus) arrangement may arise in the later branchings. When the infl. is axillary, there is usually only one at each node; in the axil of the other leaf there is a vegetative shoot, or nothing. In some of the genera (see Asclepias) the infl. is extra-axillary. The flr. is ☿, regular, 5-merous, usually small. K 5, quincuncial, the odd sepal posterior; C (5) usually rotate or campanulate, with convolute or valvate aestivation. The essential organs (5 sta., 2 cpls.) form a complex structure. The sta. and style are usually united to form a *gynostegium*. The cpls. are free below as in Apocynaceae, but united at the tip with a common style; the ovary is superior. The head of the style is large and variously shaped, and the stigmatic surface is usually upon the edge or under side of it. To its margin are united the anthers of the 5 epipetalous sta.; the filaments of these are short or non-existent. The pollen in the lower group of A. (see below) is united merely in tetrads, in the higher group, comprising the bulk of the order, into pollinia, as in Orchidaceae. Usually each anther contains two. In this group also there are curtain-like projections at the sides of the anthers, leaving a narrow slit between each pair of anthers.

The pollen is removed from the anthers by a curious mechanism—the *translator*, to borrow the new word introduced by Schumann. This differs in the two suborders and so also does the fertilisation method. The translator always stands between two anthers and serves to carry away half the pollen from each of them. In the *Periplocoideae* it is a spoon- or funnel-like body with a sticky disc at the narrow end. Into it is shed the pollen from the two half anthers next to it, and as the sticky disc projects outwards in the male stage of the flower an insect will be likely to get it attached to its head, and carry it about like the pollinia of an orchid. In visiting a second flower the pollen may be placed on the stigmatic surface. In the *Cynanchoideae*, on the other hand, there are pollinia, and the translator has a different structure. It forms an inverted λ-shaped organ, the foot of the Y being formed by the adhesive body (or *corpusculum* as it is sometimes called); from this diverge the threads (*retinacula*) which are attached to the pollinia, one in each anther. An insect in obtaining honey catches its leg in the slit between the anthers, and in drawing it up removes the pair of pollinia. The threads as they dry contract on the inner side till the pollinia meet, thus closely clasping the insect's leg. In drawing the leg through a similar slit in another flr. the pollinia catch on the stigmatic under-surface of the stylar head. (Cf. Apocynum, which shows an approach to this mechanism.)

The backs of the anthers bear as a rule curious appendages (*cuculli*) forming a *corona*. In some cases the corona springs from the corolla. It may consist simply of small teeth, or be more complex in structure, as in Asclepias and Ceropegia. It often takes up the functions of secreting and storing the honey.

The ovary is bilocular, superior, with ∞ anatropous ovules, pendulous from the ventral placentae. The fruit consists of a pair of follicles; the seeds are usually crowned by a tuft of hairs for wind-carriage. Endosperm slight, cartilaginous.

Classification and chief genera (after K. Schumann):

I. *PERIPLOCOIDEAE* (pollen in tetrads; translator spoon-like).

1. *Periploceae:* Streptocaulon, Periploca.

II. *CYNANCHOIDEAE* (pollinia; corpusculum &c.).

2. *Asclepiadeae* (pollinia pendulous on threads): Asclepias, Cynanchum.
3. *Secamoneae* (pollinia erect or horizontal, 4 in each anther): Secamone (only genus).
4. *Tylophoreae* (do. but 2 in each, erect): Ceropegia, Stapelia, Stephanotis, Hoya.
5. *Gonolobeae* (do. but 2 in each, horiz.): Gonolobus.

The order is closely related to Apocynaceae, the only absolute character of distinction being the presence of translators in *Ascl.*; otherwise the two sub-orders of each form a corresponding series, and the lower one in each is almost as nearly related to the corresponding one in the other order as to the higher group in its own order. A. are placed in Contortae by Eichler (Warming), and in Gentianales by Benth.-Hooker.

Asclepias Linn. Asclepiadaceae (II. 2). 80 sp. Am., Afr., chiefly in the U.S. (silk-weeds). Erect herbs with umbellate infls. which spring from the stem between the petioles of the opposite leaves (cf. Cuphea), or above or below this point. Two explanations are forthcoming, but which is right the evidence at present available does not show. Either the infl. is really axillary to the leaf below it and is 'adnate' to the stem (as in Cuphea), or it is the termination of a shoot, and the stem is really a sympodium.

The cuculli of the anthers form little pockets, into which honey is poured by the horn-like nectaries that project from them. Insects walking over the flowers and sipping honey frequently slip their legs down the sides of the gynostegium, and in drawing them up catch in the slit between two anthers and remove the pollinia (see order for details). The process may be watched on *A. Cornuti* Dcne. in gardens.

Asimina Adans. Anonaceae (2). 6 sp. East. U.S.

Aspalathus Linn. Leguminosae (III. 3). 150 sp. S. Afr. Many are xerophytes with a heath-like habit.

Asparagus Tourn. (incl. *Myrsiphyllum* Willd.). Liliaceae (VII). 100 sp. Old World, mostly in dry places. Rhizome with aerial shoots; leaves reduced to scales with linear green shoots in their axils, usually in tufts. These are small condensed cymes, of the type shown in the diagram (figs. represent the branches of successive orders). The number of shoots that develope varies. In the infl. the same construction holds, the shoots 2, 2, bearing the flrs. In the sub-genus M. there are flat phylloclades (cf. Ruscus). Fruit a berry. *A. officinalis* L. is largely cultivated as a vegetable; the young shoots are eaten.

stem
1
2 2
3 3
4 4
leaf

Aspasia Lindl. Orchidaceae (28). 8 sp. trop. Am.

Asperifoliae = Boraginaceae.

Asperugo (Tourn.) Linn. Boraginaceae (IV. 2). 1 sp. Eur., As.

Asperula Linn. Rubiaceae (II. 21). 80 sp. Eur., As., Austr. &c., chiefly Medit. *A. odorata* L. (woodruff) and *A. cynanchica* L. (squinancy-wort), in Brit. Flrs. homogamous. Those of the latter sp. show two forms, one with smooth white obtuse petals, one with rough reddish acute petals. The fruit of woodruff is hooked.

Asphodeline Rchb. Liliaceae (III). 14 sp. Medit.

Asphodelus (Tourn.) Linn. Liliaceae (III). 7 sp. Medit. (the Asphodel). Its leaves are isobilateral and flrs. protogynous.

Aspicarpa Rich. Malpighiaceae. 5 sp. Texas to Argentina.

Aspidistra Ker-Gawl. Liliaceae (VII). 3 sp. E. As. *A. elatior* Blume is often cultivated. The large flat style forms a lid to the cavity of the flr. made by the 8 perianth-leaves. Into this the pollen is shed, and it is supposed that the mechanism is like that of Arum. Others suggest that it is snail-fertilised.

Aspidium Sw. *Synonymy: A. aemulum* Sw., *cristatum* Sw., *dilatatum* Willd., *Filix-mas* Sw., *Oreopteris* Sw., *rigidum* Sw., *spinulosum* Sw., *Thelypteris* Sw. = Nephrodium (same spec. names); *A. Filix-foemina* Sw. = Asplenium F.-f.

Polypodiaceae 60 sp. cosmop. *A. aculeatum* Sw. (prickly shield-fern) and *A. Lonchitis* Sw. (holly-fern) in Brit.

Asplenium Linn. Polypodiaceae. About 300 sp. cosmop. 11 sp. in Brit., including *A. Filix-foemina* Bernh. (lady-fern), *A. Ruta-muraria* L. (wall-spleenwort), *A. Trichomanes* L. (spleenwort) and *A. Adiantum-nigrum* (black spleenwort). The var. *clarissima* of the lady-fern shows apogamy (see Filicineae, Lepto.). *A. bulbiferum* Forst. and other sp. are 'viviparous,' producing young plants on their leaves by vegetative budding (not to be confounded with apospory). *A. Nidus*

L. (the bird's-nest fern) is an interesting epiphyte of the Old World tropics. It bears a rosette of leaves forming a nest in which humus collects; the roots ramify in this and obtain food and water. *A. rhizophyllum* Kunze is the walking fern, so-called because the leaf-tips when they touch the soil bud into new individuals, and thus the plant spreads to some distance.

Astelia Banks et Soland. Liliaceae (VI). 9 sp. Polynes. Diœcious.

Aster Tourn. Compositae (III). 200 sp. Am., As., Afr., Eur. 2 sp. on the coast of Brit. (Michaelmas daisy), both, like so many shore plants (p. 169), somewhat fleshy. The China-aster of gardens (*A. chinensis* L.) is a sp. of Callistephus.

Asterales. The 2nd cohort of Dicotyledons (Gamopet.) in the classification of Bentham and Hooker. See p. 134.

Astilbe Buch.-Ham. Saxifragaceae (I). 6 sp. As., N. Am.

Astragalus Tourn. Leguminosae (III. 6). Abt. 1200 sp. cosmop., except Austr. 3 in Brit. (milk-vetch). The bulk are N. temp. plants living on steppes, prairies &c. and are more or less xerophytic. A great number are thorny; the thorns commonly form by the stiffening of the petiole or midrib of the leaf when the blade falls off. *A. gummifer* Labill. and others yield gum-tragacanth, obtained by wounding the stem and allowing the resin to exude and harden.

Astrantia (Tourn.) Linn. Umbelliferae (3). 5 sp. Eur., As.

Astrocarpus Neck. Resedaceae. 1 variable sp. S. W. Eur.

Astrocaryum G. F. W. Mey. Palmae (IV. 7). 29 sp. trop. Am.

Asystasia Blume. Acanthaceae (IV. B). 20 sp. Old World trop.

Atalantia Correa. Rutaceae (X). 12 sp. trop. As., China, Austr.

Athamanta Linn. Umbelliferae (6). 3 sp. Eur., W. As.

Athanasia Linn. Compositae (VII). 40 sp. S. Afr.

Athrotaxis D. Don. Coniferae (Arauc. 1*c*; see C. for genus characters). 4 sp. Tasm.

Athyrium Roth. = Asplenium Linn.

Atractylis Linn. Compositae (XI). 15 sp. Medit. to Japan.

Atragene Linn. = Clematis Linn.

Atriplex (Tourn.) Linn. Chenopodiaceae (4). 120 sp. temp. and subtrop. 6 in Brit. (orache). Flrs. unisexual, naked or with perianth.

Atropa Linn. Solanaceae (II). 2 sp. Eur., Medit., As. *A. Belladonna* L. is the deadly nightshade. It contains the alkaloid atropin, the basis of the drug belladonna used in medicine.

Attalea H. B. et K. Palmae (IV. 7). 23 sp. S. Am. *A. funifera* Mart. yields some of the Piassaba fibre of commerce.

Aubrietia Adans. Cruciferae (IV. 14). 12 sp. Medit.

Aucuba Thunb. Cornaceae. 3 sp. Himal. to Japan. *A. japonica* Thunb. is the Japan laurel of our shrubberies. It is diœcious.

Augusta Leandr. = Stifftia Mikan.

Avellinia Parl. Gramineae (X). 1 sp. Medit.

Avena Linn. Gramineae (IX). 50 sp. temp. 2 in Brit. (oat-grass). *A.*

sativa L., the cultivated oat, is perhaps derived from *A. fatua* L. It is cultivated in Eur. to 69½° N. and forms the staple of the food of a large population. [See De Candolle's *Orig. of Cult. Plts.* p. 373.] The 2—6-flowered spikelets form a loose panicle. The paleae are awned, the awn of the inf. palea being usually twisted and hygroscopic. In *A. sterilis* L. the awns cross, and when wetted try to uncurl and thus press on one another till a sort of explosion occurs jerking away the fruits.

Averrhoa Linn. Oxalidaceae. 3 or 4 sp. trop. As. (?). *A. Bilimbi* L., the Blimbing, is cultivated for its fruit, which is borne on the older stems (p. 156).

Avicennia Linn. Verbenaceae (VII). 3 sp. trop., forming one of the constituents of the mangrove-vegetation (p. 191). They have the same vivipary, habit &c., and show aerial roots projecting upwards out of the mud like those of Sonneratia.

Azalea Linn. Now united to Rhododendron Linn., from the type form of which it is chiefly distinguished by its 5 sta. and annual leaves. For *A. procumbens* L. (Brit.) see Loiseleuria.

Azara Ruiz et Pav. Flacourtiaceae. 22 sp. Mex. and S. Am., chiefly Chili. Shrubs with alt. leaves; one stipule is frequently almost as large as the leaf to which it belongs, giving the appearance of a pair of leaves not opposite to one another. The flr. is apetalous and the outer sta. often without anthers.

Azima Lam. Salvadoraceae. 2 sp. trop., Afr., As., Polyn. In the leaf axils are thorns (the leaves of an undeveloped shoot, cf. Cactaceae). Flr. polypetalous.

Azolla Lam. Salviniaceae. 4 sp. trop. and sub-trop. The general structure is like that of Salvinia. Two leaves are formed at each node, from the dorsal half of a segment of the apical cell; from the ventral half are formed roots and branches, but not at every node. The leaves are all alike; each is bilobed and has a small cavity near the base, opening to the outside by a small pore, and inhabited by the Alga *Anabaena*. The roots hang freely down in the water; usually the root cap is thrown off after a short time and the root comes almost exactly to resemble the submerged leaf of Salvinia. The sporocarps are formed in pairs (4 in *A. nilotica*) on the ventral lobes of the first leaves of the branches. Each contains one sorus. The microspores are joined together into several masses in each sporangium by the hardened frothy mucilage (epispore, cf. Salvinia). Each of these *massulae* has its outer surface provided with curious barbed hairs (*glochidia*), and escapes from the sporangium on its own account. The megasporangium contains one spore. It sinks to the bottom and at length decay of the indusium frees the spore and it germinates, giving rise to a female prothallus which floats about on the water and may be anchored to a floating massula by the barbs.

Azorella Lam. Umbelliferae (I). 35 sp. S. temp. Densely tufted xerophytes. *A. caespitosa* Vahl. is the Balsam-bog of the Falkland Is., forming tufts like those of Raoulia.

Babiana Ker-Gawl. Iridaceae (III). 30 sp. S. Afr., Socotra.

Baccaurea Lour. Euphorbiaceae (A, I. 1). 50 sp. W. Afr., E. Ind., Polynes.

Baccharis Linn. Compositae (III). 300 sp. Am. Some are leafless xerophytes with winged or cylindrical green stems.

Backhousia Hook. et Harv. Myrtaceae (2). 5 sp. Austr.

Bactris Jacq. Palmae (IV. 7). 90 sp. S. and Centr. Am. Flrs. in groups of 3, one ♀ between two ♂. *B. minor* Jacq. is the Pupunha or peach-palm, cultivated in Brazil for its edible fruit.

Baeckia Linn. Myrtaceae (2). 60 sp. Austr. to China.

Baeria Fisch. et Mey. Compositae (VI). 20 sp. Calif.

Bahia Lag. Compositae (VI). 12 sp. W. Am.

Balanophora Forst. Balanophoraceae. 11 sp. Indo-mal.

Balanophoraceae. Dicotyledons (Archichl. Santalales). 15 gen. with 40 sp., all but one trop. Parasites on tree roots, to which the tuberous rhizome is attached by suckers (p. 176). From it springs the infl. (sometimes developed within the rhizome and breaking through it), which comes above ground as a spike or head with scaly leaves and small unisexual flrs. For details and figures see *Nat. Pfl.*, or Kerner's *Nat. Hist. of Pl.* *Chief genera:* Cynomorium, Scybalium, Balanophora, Langsdorffia. [Placed in Achlamydosporeae by Benth.-Hook., in Hysterophyta by Eichler (Warming).]

Balbisia Cav. Geraniaceae. 3 sp. Chili, Peru.

Baldwinia Nutt. (*Balduina*). Compositae (V). 4 sp. N. Am.

Ballota Linn. Labiatae (V. 2). 25 sp. Eur., Medit. *B. nigra* L., the fœtid horehound, is a common weed in Brit.

Baloghia Endl. Euphorbiaceae (A, II. 5). 14 sp. E. Ind. to New Caled.

Balsaminaceae. Dicotyledons (Archichl. Sapindales). 2 gen. with 230 sp., As., Afr., Eur., N. Am. Herbs with watery translucent stems and alt. leaves, usually exstip. Flr. ☿, zygomorphic. K 5 (the 2 anterior small or aborted, the posterior one spurred), petaloid; C 5 (the lateral petals united in pairs); A 5, the anthers adhering to one another and forming a cap over the ovary, whose growth ultimately breaks the sta. at their bases; $\underline{G}$ (5), 5-loc., with ∞ ovules, anatropous, pendulous with dorsal raphe. Fruit an explosive capsule. Seed exalb. *Chief genus:* Impatiens. Benth.-Hooker unite B. with Geraniaceae (*q. v.*), but the arrangement of the ovule does not agree with that of G., being that of coh. Sapindales. Eichler and Warming place B. as an independent order in Gruinales.

Balsamodendron Kunth. = Commiphora Jacq.

Bambusa Schreb. Gramineae (XIII). 50 sp. As., Afr., Am., trop. and sub-trop. The bamboos are giant grasses, with much-branched rhizomes below ground and erect perennial woody stems above, which in some sp. reach a height of 120 ft. and a thickness of 12 inches. During the rainy season the rhizome gives off several of these shoots, which rapidly grow (sometimes 3 ft. in a day) to their full size. Spikelets 2- to many-flowered, in racemes or panicles. Some sp. flower annually, others at longer intervals, *e.g.* *B. arundinacea* Retz. every 32 years in Further India (the last time was in 1868). This phenomenon may be compared with that seen in Fagus, but seems to be largely bound up with the age of the plants, for cuttings flower simultaneously with the parent stock. The production of so many seeds at once has twice caused a plague of rats and mice in Brazil. The seedling plants grow for several years without forming tall shoots, expending their energies upon the production of the rhizomes.

The economic uses of bamboos are very numerous, especially in Asia. The stems are hollow, with cross partitions at the nodes, and the wood is elastic and very hard owing to the deposition of silica in the cell walls. The stems are used in building, entire as posts, and split as roofing tiles. They also furnish waterpipes and vessels, gutters, floats, beehives, walking sticks, pipes, flutes, &c. Split bamboo is woven into mats, &c., and used also in making umbrellas, hats, and many other articles. Paper is made from the leaf sheaths. The young shoots are eaten like asparagus, and the seeds are also used as food by the poorer natives. In the stems of *B. arundinacea* and others, curious concretions of silica are formed, known as Tabaschir and used in the East as a medicine in many diseases. For further details see the account in *Nat. Pfl.* by Sir D. Brandis, from which the above is abridged.

Banisteria Linn. Malpighiaceae. 70 sp. trop. S. Am. The fruit is remarkably like that of Acer.

Banksia Linn. Proteaceae (II). 46 sp. Austr. Shrubs and trees with the usual xerophytic habit of the order. Flrs. in dense spikes. Frt. a hard woody follicle enclosed in a number of woody twigs derived from the bract and bracteoles. Seeds winged.

Baptisia Vent. Leguminosae (III. 2). 14 sp. N. Am. In *B. perfoliata* R. Br. there are perfoliate leaves which are really in two vertical ranks, but become one-ranked by twisting of the internodes alternately right and left.

Barbarea R. Br. Cruciferae (II. 11). 14 sp. Eur., Medit., As., N. Am. 2 in Brit. (yellow rocket or winter-cress).

Barclaya Wall. Nymphaeaceae (III). 3 sp. Indo-mal. K 5 hypogynous; C up to (21), epigynous, tubular; A ∞; G (10—12) with projections forming a tube above the stigmatic disc.

Barkhausia Moench. = Crepis Linn.

Barleria Linn. Acanthaceae (IV. A). 100 sp. trop., mostly on steppes. The bracteoles are frequently represented by thorns. The seeds have surface hairs which swell when wetted and help to anchor them to suitable places for germination (p. 106).

Barnadesia Mutis. Compositae (XII). 12 sp. S. Am. Shrubs.

Barosma Willd. Rutaceae (IV). 15 sp. S. Afr.

Barringtonia Forst. Lecythidaceae. 30 sp. E. Afr. to Samoa. The wood of some sp. is useful and the seeds yield oil, used for lamps.

Bartonia Muhl. Gentianaceae (I. 2). 3 sp. N. Am. Saprophytes with a little chlorophyll and leaves reduced to scales.

do. Sims. (in Loasaceae) = Mentzelia Linn.

Bartramia Linn. = Triumfetta Linn.

Bartsia Linn. (incl. *Odontites* Hall.). Scrophulariaceae (III. 12). 60 sp. N. temp., trop. Mts., and S. Am. *B. Odontites* Huds. and 2 others, in Brit. Mostly herbs, semi-parasitic (on grass-roots, see order). Flr. with loose-pollen mechanism (see order).

Basella (Rheede) Linn. Basellaceae. 1 sp. trop. As. A climbing herb whose flrs. remain closed; their mechanism requires investigation. The fruit is enclosed in the perianth.

Basellaceae. Dicotyledons (Archichl. Centrospermae). A small family united with Chenopodiaceae by Benth.-Hooker and Warming, but differing in their internal anatomy as well as in morphology. They possess an underground rhizome or tuber, giving off annually a climbing shoot, often with fleshy leaves, and racemes or panicles of flrs. These are stalked and often conspicuously coloured. Each has 2 bracteoles, 2 sepals, and 5 petals. Opposite these are 5 sta. Ovary superior, of 3 cpls., with terminal style and 3 stigmas, unilocular. Ovule 1, basal, campylotropous. Fruit usually a berry. *Chief genera:* Basella, Ullucus, Boussingaultia.

Bassia Koenig. (*Illipe* F. Muell.). Sapotaceae (I). 30 sp. Indo-mal. &c. *B. pallida* Burck. yields a gutta-percha. The seeds of *B. butyracea* Roxb. yield a butter-like substance, used for soap-making &c. The flrs. of *B. latifolia* Roxb., the Moa or Mahwah, are edible, and the wood valuable.

Batatas Choisy. = Ipomaea Linn. (*B. edulis* Ch. = *I. Batatas* Poir.).

Batidaceae. Dicotyledons (Archichl. Centrospermae). Only genus Batis (*q.v.*). See *Nat. Pfl.* Placed in Curvembryae by Benth.-Hooker and Warming.

Batis Linn. Batidaceae. 1 (or more?) sp., coasts N. Am.

Batrachium S. F. Gray = Ranunculus Tourn. (the aquatic sp.).

Batschia Vahl. = Humboldtia Vahl. (Leguminosae).

Bauera Banks. Saxifragaceae (VII). 3 sp. temp. E. Austr. Shrubs. Flrs. solitary, axillary, 4—10-merous. Sta. = pet. or ∞.

Bauhinia Linn. Leguminosae (II. 4). 150 sp. trop. Many are lianes (p. 173). Their stems are curiously shaped, flattened or corrugated and twisted in various ways (figs. in Kerner's *Nat. Hist. of Pl.*). "One is the most extraordinary among the climbers of the forest, its broad flattened woody stems being twisted in and out in a most singular manner, mounting to the summits of the very loftiest forest trees and hanging from their branches in gigantic festoons many hundred feet in length" (Wallace, *Amaz.*). Some sp. have tendrils (branches). The stem of the climbing sp. has a peculiar mode of growth in thickness (cf. other lianes and see De Bary's *Anat.* or *Nat. Pfl.*). In some the young leaves droop like those of other trop. plants (p. 157). In the axils of the stipules are usually found small linear trichome structures; in some sp. they form stout interstipular thorns. Great variety occurs in the floral structure (see *Nat. Pfl.*).

Beaucarnea Lem. = Nolina Michx.

Beaufortia R. Br. Myrtaceae (2). 13 sp. W. Austr. Some sp. are cultivated in greenhouses for their showy flrs.

Beaumontia Wall. Apocynaceae (II. 4). 4 sp. E. Ind.

Beckmannia Host. Gramineae (x). 1 sp. N. temp.

Begonia (Tourn.) Linn. Begoniaceae. Over 400 sp. trop., especially in Am. Many are cultivated in our greenhouses for their handsome flrs. and foliage. Most are perennial herbs with thick rhizomes or tubers. Several climb by aid of roots like ivy. Leaves radical or alt., in two ranks, with large stipules. One side of the leaf is larger than the other, whence the name 'elephant's ear,' by which they are sometimes known. The surface of the leaf is easily wetted, and drip-tips are frequent (p. 143 and art. *Ficus*). In the leaf axils groups of little tubers are frequently found; these are not axillary branches, but are borne upon the true axillary branch, which does not lengthen. Begonias also reproduce very easily by means of adventitious buds (p. 113). These readily form on pieces of leaves cut off and placed on the soil under suitable conditions of moisture &c. (this is the common mode of multiplication used in horticulture). A callus forms over the wound, and in it there develops a meristem which gives rise to one or more buds.

The infl. is axillary, dichasial with a bostryx tendency (p. 64). The first axes usually end in ♂, the last and sometimes the last but one in ♀, flrs. In the ♂, perianth 2, valvate, or 4, decussate, corolline; sta. ∞, free or not, the connective often elongated and the anthers variously shaped. In the ♀, perianth 2—5; ovary inf., usually (2—3), with 2—3 loculi, and axile placentae often projecting far into them; ovules ∞, anatropous; styles more or less free. The ovary is usually winged and the wings are persistent upon the capsular frt. Seeds without endosperm.

Begoniaceae. Dicotyledons (Archichl. Parietales). 4 gen. with the characters of Begonia (*q.v.*). Placed in Passiflorinae by Warming, in Passiflorales by Benth.-Hooker.

Bellis (Tourn.) Linn. Compositae (III). 10 sp. Eur., Medit. *B. perennis* L. is the common daisy. It multiplies largely, and also hibernates, by means of short rhizomes. The ray florets are ♀. The head closes at night and in wet weather.

Bellium Linn. Compositae (III). 6 sp. Medit.

Bencomia Webb. et Berth. Rosaceae (III. 9). 2 sp. Canaries, Madeira (p. 148).

Benincasa Savi. Cucurbitaceae (III). 2 sp. trop. As. The frt. of *B. cerifera* Savi. is eaten in curries. It has a thick coating of wax.

Benthamia Lindl. (1830) = Amsinckia Lehm.; (1833) = Cornus Tourn.

Bentinckia Berry. Palmae (IV. 6). 2 sp. Ind.

Benzoin Nees = Lindera Thunb. *do.* Hayne = Styrax Linn.

Berberidaceae. Dicotyledons (Archichl. Ranales). 11 gen. with 135 sp., N. temp. (Berberis in trop. Mts. and S. Am.). Perennial herbs or shrubs, in the former case usually with sympodial rhizome. Flrs. in racemes, ☿, regular. The typical formula is P $3+3+3+3$, A $3+3$, $\underline{G}$ 1; the flr. is sometimes 2-merous. Of the 4 outer whorls, the two outer are perianth proper, the two inner "honey-leaves" usually with nectaries at the base (see Ranunculaceae). The former are often termed the calyx, the latter the corolla. The anthers are introrse, but in most cases open by two valves (cf. Lauraceae) at the back; the valve with the pollen on it moves upwards and turns round so that the pollen faces towards the centre of the flr. Cpl. always 1, with one or many ovules, in the former case usually basal, in the latter ventral. Fruit a berry, or a dry fruit opening in various ways. Embryo straight in rich endosperm. *Chief genera:* Podophyllum, Epimedium, Leontice, Berberis. Placed in Polycarpicae by Eichler (Warming). See next art.

Berberideae (Benth.-Hook.) includes preceding order and Lardizabalaceae. Placed in coh. Ranales.

Berberis (Tourn.) Linn. Berberidaceae. 100 sp. N. temp., Andes, S. Am. *B. vulgaris* L. (the barberry) in Brit. Shrubs. The genus is divided into two sections. In § 1, *Mahonia* (Nutt.), the leaves are pinnate; many sp. are cultivated in shrubberies. In § 2, *Euberberis*, the leaves are simple, but usually show a joint where the blade meets the petiole, seeming to indicate a derivation from a compound leaf. There are also 'short' and 'long' shoots (cf. Coniferae) in this section, to which *B. vulgaris* belongs. The latter have their leaves metamorphosed into spines (usually tripartite); transitions may often be seen. The former stand in the axils of the spines and bear green leaves and racemes of flrs. (afterwards sometimes elongating to 'long' shoots). The flr. has the structure typical of the order; its pollination mechanism is interesting. The upper surface of the base of each sta. is sensitive to contact, and when it is touched by an insect in search of honey (secreted by the nectaries upon the bases of the inner perianth leaves) the sta. springs violently upwards, covering the side of the visitor's head with pollen, which it may place on the stigma in the next flr. visited. The fruit is sometimes made into preserves.

A very interesting point about the common barberry is its connection with the disease known as *rust*, which occurs on wheat and other

Gramineae. The fungus (*Puccinia graminis* or *Aecidium berberidis*) passes through two alternating stages in its life history, one on the grass, the other on the barberry, so that if there are no barberry plants in a district, it is practically insured against rust. See text-books, or Ward's *Diseases of Plants*.

Bergenia Moench. = Saxifraga Tourn. (7 sp. As.)

Berkheya Ehrh. Compositae (X). 70 sp. Afr.

Bernoullia Oliv. Sterculiaceae. 1 sp. Guatemala.

Berrya Roxb. Tiliaceae. 2 sp. Ceylon, E. Ind., Tahiti.

Berteroa DC. = Alyssum Tourn. (5 sp. Eur., As., Medit.)

Bertholletia Humb. et Bonpl. Lecythidaceae. 2 sp. trop. S. Am. The frt. is a large woody capsule, containing seeds with hard woody testa and oily endosperm—the Brazil nuts of commerce. "This tree takes more than a year to produce and ripen its fruits. In... January I observed the trees loaded at the same time with flowers and ripe fruits....The fruits, nearly as hard and heavy as cannon-balls, fall with tremendous force from the height of 100 feet....Persons are sometimes killed by them" (Wallace). The fruit is indehiscent and the seeds are procured by opening it with an axe.

Bertolonia Raddi. Melastomaceae (I). 9 sp. S. Brazil. Young plants form readily at cuts across the midrib of a leaf placed on damp soil (p. 113).

Beschorneria Kunth. Amaryllidaceae (II). 13 sp. Mex. Like Agave.

Besleria Plum. Gesneraceae (I). 50 sp. trop. and sub-trop. Am.

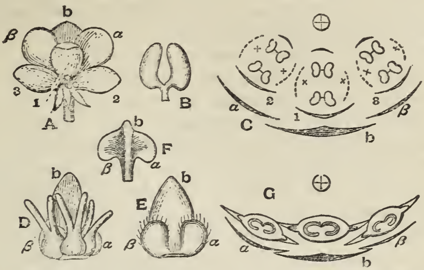
Bessera Schult. f. (excl. *Androstephium* Torr.). Liliaceae (IV). 1 sp. Mex.

Beta (Tourn.) Linn. Chenopodiaceae (2). 6 sp. Eur., Medit.; 1 in Brit., *B. vulgaris* L. or *B. maritima* L. the sea-beet, from which are derived the garden beetroot, the sugar-beet, and the mangold-wurzel. The plant is a biennial (p. 151) and stores reserves in the root, the non-nitrogenous materials taking the form of sugar. The sugar-beet is largely cultivated in Western Europe for the sake of this sugar. The garden beet is a favourite vegetable; the mangold is valuable for feeding cattle, &c. The leaves are sometimes eaten like spinach.

Betonica (Tourn.) Linn. = Stachys Tourn.

Betula (Tourn.) Linn. Betulaceae. 35 sp. N. temp. *B. alba* L., the birch, is common in Brit. and reaches to the N. limit of trees (p. 180). Trees with catkins of flrs. The ♂ catkins are laid down in autumn as large buds at the end of the year's growth, the ♀ further back, on leafy branches. In the axil of each leaf of the catkin there are 3 flrs. (cf. other genera of the order). The bracts of the lateral flrs. occur (α, β) but no bracteoles. In the ♂ the bracteoles α β are joined to the bract itself. Each flr. has two sta. and a perianth, often reduced from the typical 4 leaves to the 2 median leaves, or even to the single anterior leaf. The sta. are divided into halves nearly to the base; the lateral ones are absent. In the ♀ the bracteoles α β

are free from the bract at the time of fertilisation, but afterwards they unite with it to form the 3-lobed woody scale (*F* in figure) under the



B. alba. *A*, bract, bracteoles, and perianth, of ♂, from within, with sta. removed; *B*, a stamen; *C*, floral diagram of *A*; *D*, bract, bracteoles and flrs. of ♀ from within; *E*, the same with flrs. removed; *F*, the same at ripeness of seed; *G*, floral diagram of *D*. *b*=bract; α, β=bracteoles of flr. 1, or bracts of flrs. 2, 3. After Eichler.

fruit (or rather the tissue beneath them grows up, carrying all up together; see p. 30). The 2-locular ovary gives rise to a 1-seeded nut, attached to the scale. There is no perianth.

Birch-wood is tough and is used for various purposes, *e.g.* for wooden shoes and for charcoal. The oil prepared from the bark is used in tanning Russia leather, to which it gives its peculiar fragrance. The bark of *B. papyracea* Ait. (N. Am.) is used in making canoes.

Betulaceae. Dicotyledons (Archichl. Fagales). 6 gen. with 75 sp., chiefly N. temp. Shrubs or trees with undivided stipulate leaves. The seedling stems are radial in symmetry, but in the old branches the leaves are often 2-ranked and face upwards (p. 47). The membranous stipules soon drop off. Flrs. monœcious, in terminal catkins; the stem is thus sympodial. In the axils of the leaves of the catkins are small dichasial cymes, typically of 3 flrs. (see Betula, &c.). The central flr. is often absent, and some of the bracteoles also. The ♂ flr. is united to the bract and may have a perianth; sta. 2—10. The ♀ may have an epigynous perianth. Cpls. (2). Ovary inferior, 2-loc. with 1 pendulous ovule in each loc. Some genera are chalazogamic; see Chalazogamae. Nut 1-seeded; seed exalbuminous. After fertilisation the bract and bracteoles grow into a scale- or cup-like organ which may remain attached to the fruit. *Genera:* Ostryopsis, Carpinus, Ostrya, Corylus, Betula, Alnus. The order is placed in Querciflorae by Eichler, and united to Fagaceae (Cupuliferae) by Benth.-Hooker.

Biarum Schott. Araceae (VII). 7 sp. Medit.

Bicarpellatae (Benth.-Hooker). The 3rd series of Gamopetalae (p. 135).

Bicornes (Warming). The 1st cohort of Sympetalae (p. 137).

Bidens (Tourn.) Linn. Compositae (v). 90 sp. cosmop. 2 in Brit. (bur-marigold). The fruit is animal-distributed by aid of the 2-6 barbed bristles of the pappus. *B. Beckii* Torr. (N. Am.) is a water-plant with two kinds of leaves (p. 163).

Biebersteinia Steph. Geraniaceae. 4 sp. Orient.

Bifrenaria Lindl. Orchidaceae (18). 10 sp. trop. S. Am.

Bigelowia DC. Compositae (III). 34 sp. N. Am.

Bignonia (Tourn.) Linn. (incl. *Cremastus* Miers, *Cydista* Miers, *Doxantha* Miers, *Paragonia* Bur., *Phaedranthus* Miers, *Pleonotoma* Miers, *Pyrostegia* Presl., *Stizophyllum* Miers, all regarded as independent genera by Schumann in *Nat. Pfl.*). Bignoniaceae (I). 150 sp. Am., mostly lianes. In *B. Tweediana* Lindl. the tendril is grapnel-like with three sharp claws. The stem twines, and both petioles and tendrils are sensitive to contact. When either curves round the support, the claws catch hold of their own stalk or the stem as they come round. After clasping the tendril thickens and becomes woody. In *B. capreolata* L. the tendrils are bluntly hooked and show great negative heliotropism. When the tip enters a crevice it forms a ball of parenchyma, secreting cement (cf. Vitis). Then the free part contracts spirally and becomes woody. Several sp. are cultivated for their showy protandrous flrs.

Bignoniaceae. Dicotyledons (Sympet. Tubiflorae). About 60 gen. with 500 sp. trop. There are no sp. and only one genus (Catalpa) common to the old and new worlds. Most occur in Brazil; a few are found in temp. regions. They are trees and shrubs, most commonly lianes, with opp. usually compound exstip. leaves. A considerable number are xerophytic shrubs with condensed stems, but the chief interest of the order centres in the climbers, which form a very important feature in the forest vegetation of S. Am. There are twiners (*e.g.* Tecomaria, Pandorea), root-climbers (*Tecoma radicans*), and tendril climbers (most B.). In Eccremocarpus &c. the internodes and petioles are sensitive, but in most B. the tendrils are at the ends of the leaves (in place of leaflets, as in Vicia). The tendrils are frequently branched: in some cases, *e.g.* Bignonia, the branched tendril occupies the place of one leaflet. Three types of tendril are found—simple twiners, tendrils provided with adhesive discs (as in virginia creeper), and hooked tendrils. See Glaziovia, Bignonia &c. The climbing stems exhibit many features of anatomical interest, owing to their peculiar growth in thickness (p. 173).

Infl. usually dichasial with cincinnal tendency (p. 52); bracts and bracteoles present. Flr. ☿, zygomorphic, hypogynous. K (5): C (5), usually bell- or funnel-shaped, descendingly imbricate; A 4, epipetalous, didynamous, the anther-lobes usually one above the other, the posterior staminode always present; $\underline{G}$ (2) on hypogynous disc, 2- (or rarely 1-) loc., with ∞ erect anatropous ovules on axile placentae. Capsule septifragal or loculicidal: seed usually flattened and with large membranous wing, exalbuminous.

Classification and chief genera (after Schumann):

I. *BIGNONIEAE* (ovary completely 2-loc., compressed ‖ septum, or cylindrical; capsule septifragal, with winged seeds; usually tendrillate): Glaziovia, Bignonia.

II. *TECOMEAE* (ovary 2-loc., compressed ⊥ septum or cylindrical; capsule loculicidal with winged seeds; rarely tendrillate): Incarvillea, Jacaranda, Catalpa, Tecoma.

III. *ECCREMOCARPEAE* (ovary 1-loc.; capsule splits from below upwards; seeds winged; tendrils): Eccremocarpus (only gen.).

IV. *CRESCENTIEAE* (ovary 1- or 2-loc.; fruit berry or dry indehiscent; seeds not winged; usually erect plants): Crescentia, Phyllarthron.

V. *TOURRETTIEAE* (ovary 4-loc.; hooked capsule): Tourrettia (only gen.).

The order is placed in Personales by Benth.-Hooker, in Personatae by Eichler (Warming).

Billardiera Sm. Pittosporaceae. 8 sp. Austr.

Billbergia Thunb. Bromeliaceae (1). 40 sp. trop. Am. Epiphytes.

Biophytum DC. Oxalidaceae. 20 sp. trop. *B. sensitivum* DC. has pinnate leaves, sensitive to contact (cf. Mimosa). When touched the leaflets bend downwards. The seed has an explosive aril (cf. Oxalis); the capsule spreads out flat when it dehisces and thus allows the seeds to escape easily.

Biota D. Don. = Thuja Linn. (all sp. of B. = T. orientalis).

Biscutella Linn. Cruciferae (II. 5). 12 sp. Eur.

Biserrula Linn. Leguminosae (III. 6). 1 sp. Medit. The frt. is very like a centipede, and it has been suggested that birds are deceived by it and carry it to a distance before discovering their mistake.

Bismarckia Hildebr. et H. Wendl. Palmae (II. 3). 1 sp. Madag. Included in Medemia in *Nat. Pfl.*

Bixa Linn. Bixaceae. 1 sp., *B. Orellana* L., trop. Am. Cultivated all over the Tropics for its seed. The outer layer of the testa is red and fleshy; the orange-yellow colouring matter (annatto, arnotto, &c.) is used in dyeing sweetmeats &c.

Bixaceae. Dicotyledons (Archichl. Parietales). 4 gen. with 19 sp., trop. Small trees or shrubs, sometimes with tuberous underground stem; leaves alt., stipulate, usually large and lobed. Schizogenous mucilage canals are present in the tissues, and resin cells in the leaf parenchyma in most sp. Flrs. in panicles, ☿, regular. K 4—5, imbricate; C 4—5, imbricate or convolute; A ∞, sometimes united at base, the anthers usually opening by short slits or pores; G (2—5), 1-loc. with parietal placentae, or more or less completely multi-loc. by union of the placentae in the centre. Ovules ∞, anatropous. Style simple. Frt. a capsule; seeds ∞ with rich endosperm; embryo usually curved. As defined by Warburg in *Nat. Pfl.* this order consists of the 4 gen. Bixa, Cochlospermum, Amoreuxia, and Sphaerosepalum. The latter was formerly placed in Guttiferae. B. are placed in Cistiflorae by Warming (Eichler), and in Parietales by Benth.-Hooker. These authors all include in B. the Flacourtiaceae, treated as a separate order by Engler.

Bixineae (Benth.-Hooker) = Bixaceae (in wide sense; see above).

Blackstonia Huds. = Chlora Ren.

Blaeria Linn. Ericaceae (IV. 9). 15 sp. Afr.

Blakea P. Br. Melastomaceae (I). 30 sp. S. Am., W. Ind.

Blandfordia Sm. Liliaceae (III). 4 sp. E. Austr.

Blatti Adans. = Sonneratia Linn. f.

Blattiaceae. Dicotyledons (Archichl. Myrtiflorae). 3 gen. with 12 sp., Old World trop. They are united to Lythraceae by Benth.-Hooker, but differ in the ovary, which is usually united to the receptacle and has parietal or sub-basal placentae. Chief genus Sonneratia (Blatti).

Blechnum Linn. Polypodiaceae. 20 sp. trop. and temp. The British fern *B. boreale* Sw. or *B. Spicant* Roth. = *Lomaria S.* Desv.

Blepharipappus Hook. Compositae (V). 1 sp. W. N. Am.

Blepharis Juss. Acanthaceae (IV. B). 40 sp. trop. and sub-trop., Old World. Thistle-like plants with the characters of Acanthus. The seeds have hairs which swell up when wetted.

Bletia Ruiz et Pav. Orchidaceae (15). 20 sp. trop. Am. Epiphytes. For *B. hyacinthina* R. Br. see next art.

Bletilla Reichb. f. Orchidaceae (5). 1 sp. China, Japan.

Blighea Kon. Sapindaceae (I). 1 sp. trop. Afr., *B. sapida* Kon., cultivated for its frt. The edible part is the fleshy arillate seed-stalk.

Bloomeria Kellogg. Liliaceae (IV). 2 sp. Calif.

Blumea DC. Compositae (IV). 60 sp. trop. and sub-trop., Old World.

Blumenbachia Schrad. (incl. *Caiophora* Presl.). Loasaceae (III). 55 sp. S. Am. The flr. is like that of Loasa. The frt. is twisted and is very light. It is covered with grapnel hairs and clings closely to fur; as it is carried about the seeds are gradually shaken out.

Blysmus Panz. = Scirpus Tourn.

Bobartia Linn. Iridaceae (II). 6 sp. S. Afr. Leaves sword-like, or centric like those of onions.

Bocconia Plum. (incl. *Macleya* Reichb.). Papaveraceae (II). 3 sp., 2 in trop. Am., the other, *B.* (*M.*) *cordata* Willd., in China and Japan. Flr. apetalous.

Boehmeria Jacq. Urticaceae (3). 45 sp. trop. and N. temp. *B. nivea* Gaudich. has good "drip-tips" on its leaves (see art. *Ficus*). It is largely cultivated in China for the excellent fibre (Rhea or Chinese grass-cloth) obtained from the inner bark (cf. Linum).

Boerhaavia Vaill. Nyctaginaceae (I). 20 sp. Afr., trop. As., Am. The anthocarp is often glandular, aiding in seed-distribution.

Bolbophyllum Spreng. = Bulbophyllum Thou.
Boldoa Endl. = Peumus Molina.
Boltonia L'Hérit. Compositae (III). 3 sp. U.S.
Bomarea Mirb. Amaryllidaceae (III). 50 sp. S. Am. Like Alstroemeria in leaf and flr., but often climbing. Umbels cymose.
Bombacaceae. Dicotyledons (Archichl. Malvales). 20 gen. with 110 sp. trop. (chiefly Am.). Trees, often very large, with thick stems, sometimes egg-shaped, owing to a great development of water-storage tissue (see figs. in Kerner, *Nat. Hist. of Plts.* 1). Flrs. ☿, usually regular. K (5), valvate, often with epicalyx; C 5, convolute, the pets. asymmetric; A 5—∞, free or united into a tube, the pollen smooth; $\underline{G}$ (2—5), in the latter case the cpls. opposite the pets., multiloc.; style simple, lobed or capitate; ovules 2—∞ in each loc., erect, anatropous. Seeds smooth, but often embedded in hairs springing from the capsule wall, with little or no endosperm. The order is united to Malvaceae by Eichler (Warming) and Benth.-Hooker.

Chief genera: Adansonia, Bombax, Eriodendron, Durio.

Bombax Linn. (excl. *Pachira* Aubl.). Bombacaceae. 50 sp. trop.
Bonatea Willd. = Habenaria Willd.
Bongardia C. A. Mey. Berberidaceae. 1 sp. Greece to Cent. As.
Bontia Linn. Myoporaceae. 1 sp. W. Ind.
Boopis Juss. Calyceraceae. 10 sp. S. Am.
Boraginaceae. Dicotyledons (Sympet. Tubiflorae). About 85 gen. with 1200 sp., trop. and temp., esp. Medit. Most are herbs, perennial by fleshy roots, rhizomes, &c.; a few shrubs and trees. Leaves usually alt., exstip., generally, as well as the rest of the plant, covered with stout hairs (hence the name Asperifolieae, by which the B. are sometimes known). The infl. is a coiled cincinnus, sometimes double, with a marked dorsiventrality. As the flrs. open it uncoils, so that the newly opened flrs. face always in the same direction (the morphology of this infl. is very imperfectly understood; "adnation" occurs, and dichotomy at the growing apex; see *Nat. Pfl.* &c.).

Flr. ☿, usually regular, hypogynous, and 5-merous. K (5), imbricate or open, the odd sepal posterior; C (5), funnel-shaped or tubular, the limb usually flat; A 5, epipet., alternate to petals, anthers introrse; $\underline{G}$ (2), on hypogynous disc, 4-locular by 'false' septum (see Labiatae), usually with gynobasic style; ovules 1 in each loc., erect, anatropous. Fruit a drupe or 4 achenes. Seed with straight or curved embryo in slight endosperm; the radicle directed upwards.

The floral arrangements are interesting. Most B. have a short tube, partly concealing the honey; many (esp. IV. 1 and 3) have scales projecting inwards from the throat of the corolla, thus fully concealing the honey, protecting it from robbery and narrowing the entrance, so that visiting insects must take a definite track. "The lower forms (*e.g.* Myosotis) are visited by flies (esp. Syrphidae), bees, and Lepidoptera, and are adorned with red, violet and blue colours.

...Many sp., in the course of their individual development, seem to recapitulate to us the evolution of their colours—white, rosy, blue in several sp. of Myosotis; yellow, bluish, violet in *M. versicolor*; and red, violet, blue in Pulmonaria, Echium &c. Here, white and yellow seem to have been the primitive colours; and, at least in many cases, violet and blue seem to have been preceded by red—an assumption which is strengthened by the fact that many blue and violet sp. (Myosotis, Anchusa, Symphytum) give us white and rose-red varieties, apparently by reversion to more primitive characters." (Müller.)

Many B. are heterostyled, *e.g.* Pulmonaria. The flrs. of many sp. are pendulous (and thus bee-flowers), *e.g.* Borago, Symphytum. Echium is gynodiœcious.

Classification and chief genera (after Gürke):

A. Style terminal: drupe.
 I. *CORDIOIDEAE* (style twice bi-lobed): Cordia.
 II. *EHRETIOIDEAE* (style simple or bi-lobed or double; no ring of hairs): Ehretia.
 III. *HELIOTROPIOIDEAE* (ditto, but ring of hairs near tip of style): Tournefortia, Heliotropium.

B. Style gynobasic: achenes.
 IV. *BORAGINOIDEAE:*
  a. Achenes 4.
   1. *Cynoglosseae* (flr. reg.; base of style more or less conical; tips of achenes not projecting above pt. of attachment): Omphalodes, Cynoglossum, Rindera.
   2. *Eritrichieae* (do., but tips projecting above pt. of attachment): Echinospermum, Eritrichium, Cryptanthe.
   3. *Anchuseae* (flr. reg.; base of style flat or slightly convex; achenes with concave attachment surface): Symphytum, Borago, Anchusa, Alkanna, Pulmonaria.
   4. *Lithospermeae* (do., but surface of attachment flat): Myosotis, Lithospermum, Arnebia, Cerinthe.
   5. *Echieae* (flr. zygomorphic): Echium.
  b. Achenes more or less than 4.
   6. *Harpagonelleae* (ach. 2): Harpagonella, Rochelia (only gen.).
   7. *Zoellerieae* (ach. 10): Zoelleria (only gen.).

[Placed in Nuculiferae by Eichler (Warming), in Polemoniales by Benth.-Hooker.]

Boragineae (Benth.-Hooker) = Boraginaceae.

Borago Linn. Boraginaceae (IV. 3). 3 sp. Medit., Eur., As. *B. officinalis* L. in Brit. The borage is largely cultivated for bee feeding. It has a typical bee-flower. The blue pendulous flr. secretes honey below the ovary; the elastic sta. form a cone and dehisce introrsely from apex to base, the pollen ripening gradually and trickling into the tip of the cone. Insects probing for honey dislocate the sta., receiving a shower of pollen (cf. Erica, Galanthus, Cyclamen). In older flowers the stigma, now ripe, projects beyond the sta. so as to be touched first.

Borassus Linn. Palmae (II. 3). 1 sp., *B. flabellifer* L., the Palmyra palm, in trop. Afr. and As. Diœcious. Its uses are legion; an old Tamil song enumerates 801! The chief is perhaps the production of palm-wine or toddy, obtained by tapping the sap flowing to an infl. (cf. Agave), and fermenting it.

Borbonia Linn. Leguminosae (III. 3). 13 sp. S. Afr.

Boretta Neck. = Dabeocía D. Don.

Boronia Sm. Rutaceae (III). 60 sp. Austr.

Borreria G. F. W. Mey. = Spermacoce Linn.

Bossiaea Vent. Leguminosae (III. 3). 34 sp. Austr. Several xerophytic sp. have flattened green stems (phylloclades) with minute scaly leaves. As in Acacia &c., seedlings show transitions from normal leaves.

Boswellia Roxb. Burseraceae. 10 sp. India, Afr. *B. Carteri* Birdw. (Somaliland and Hadramaut) yields the resin known as frankincense or gum-olibanum, obtained by notching the stem. It was formerly officinal, but is now chiefly used in incense. Other sp. also yield fragrant resins.

Botrychium Sw. Ophioglossaceae. 6 sp. temp. and trop. *B. Lunaria* Sw., the moon-wort, is found in many places in Britain, but not abundantly. The general habit resembles that of Ophioglossum, but the sterile as well as the fertile part of the leaf is usually branched. The roots appear one at the base of each leaf, and branch monopodially. The spike is usually much branched, the ultimate twigs being the sporangia.

Boucerosia Wight et Arn. Asclepiadaceae (II. 4). 20 sp. Medit., trop. Afr. and As. Like Stapelia. Included in Caralluma R. Br. in *Nat. Pfl.*

Bougainvillaea Comm. Nyctaginaceae (I). 7 sp. S. Am. The group of 3 flrs. is surrounded by 3 lilac-coloured bracts, which persist and act as wings for the fruits.

Boussingaultia H. B. et K. Basellaceae. 10 sp. trop. Am.

Bouteloua Lag. Gramineae (XI). 30 sp. S.-West U. S., the mezquit grasses, which form a large portion of the herbage of the prairie, and are valuable as fodder.

Bouvardia Salisb. Rubiaceae (I. 4). 30 sp. trop. Am. Some are heterostyled like Primula. Often cultivated for their flrs.

Bowenia Hook. Cycadaceae. 1 sp. Queensland. Easily recognised by its bipinnate leaf (see order).

Bowiea Harv. Liliaceae (III). 1 sp. Cape Col., *B. volubilis* Harv. It is a xerophyte like Testudinaria, with a large partly underground stock (corm), giving off each year a much-branched climbing stem. This bears small leaves, but they soon drop off, and assimilation is carried on by the green tissue of the stem.

Bowlesia Ruiz et Pav. Umbelliferae (2). 12 sp. Am., Canary Is.

Boykinia Nutt. Saxifragaceae (I). 7 sp. N. Am., Japan.

Brachycome Cass. Compositae (III). 50 sp. Austr., N. Z., N. Am., Afr.

Brachypodium Beauv. Gramineae (X). 6 sp. temp. (and trop. Mts.). 2 in Brit. (false brome grass). Leaf reversed (cf. Alstroemeria).

Brachysema R. Br. Leguminosae (III. 2). 14 sp. Austr.

Bradburya Rafin. = Wistaria Nutt. and Centrosema Benth.

Brahea Mart. Palmae (I. 2). 2 sp. Mexico, Texas.

Brainea Hk. Polypodiaceae. 1 sp. Hong-kong and Khasia, *B. insignis* Hk., a dwarf tree-fern. The primary veins branch and rejoin repeatedly, forming small areas in the leaf; the veinlets run parallel and distinct.

Brasenia Schreb. Nymphaeaceae (II). 1 sp. cosmop., except Eur. Sta. 12 or more.

Brassavola R. Br. Orchidaceae (13). 20 sp. trop. Am.

Brassia R. Br. Orchidaceae (28). 30 sp. trop. Am.

Brassica (Tourn.) Linn. (incl. *Erucastrum* Presl. and *Sinapis* L.). Cruciferae (II. 10). 85 sp. Eur., Medit., As. 7 in Brit. Many forms of this genus are cultivated, some for the flr., others for the stem, root, leaf, or seed. *B.* (*S.*) *nigra* Koch is the black mustard, whose ground seeds form the familiar condiment; *B.* (*S.*) *alba* Boiss. is the white mustard, used when young in salads &c.; *B. sinapis* Vis. (*S. arvensis* L.) is the charlock, one of the most abundant weeds of cultivation (in summer our corn-fields are yellow with it). *B. oleracea* L. is the cabbage, with the various races derived from it, such as cauliflower and brocoli (fleshy infl.), kale, brussels-sprouts (a form in which miniature cabbages are produced in all the leaf-axils on the main stem), kohl-rabi (a thickened stem, or corm, showing leaf scars on its surface), &c. *B. campestris* L. is the turnip, a biennial with thickened root, and a variety of it—*B. Napus* L.—is the rape, used in salads and in the preparation of rape- or colza-oil, expressed from the seeds. [See De Candolle's *Orig. of Cultiv. Plts.*] It is of interest to notice here the great variety of morphology in the vegetative organs, correlated with the different ways in which storage of reserve materials is effected, in the root, stem, leaf, flowerstalk &c.

The outer coat of the seed has mucilaginous cell-walls which swell when wetted and help to fasten the seed to its place of germination (cf. Linum).

Bravoa Lex. Amaryllidaceae (II). 3 sp. Mexico. Rhizome with tuberous roots. Flr. zygomorphic by bending.

Braya Sternb. et Hoppe. Cruciferae (IV. 18). 8 sp. Mts. of Eur., As.

Brevoortia Wood. Liliaceae (IV). 1 sp. Calif.

Breweria R. Br. Convolvulaceae (I. 2). 27 sp. trop.

Brexia Noronha. Saxifragaceae (V). 1 sp. Madag., Seychelles.

Brickellia Ell. Compositae (II). 60 sp. trop. and sub-trop. Am.

Bridelia Willd. Euphorbiaceae (A, I. 2). 30 sp. trop., W. Afr. to New Caled.

Bridgesia Hook. et Arn. = Ercilla A. Juss.

Briza Linn. Gramineae (X). 12 sp. temp. 2 in Brit. (*B. media* L., and *B. minor* L., quake-grasses).

Brocchinia Schult. f. Bromeliaceae (2). 3 sp. trop. Am., W. Ind.

Brodiaea Sm. (incl. *Calliprora* Lindl.). Liliaceae (IV). 30 sp. Am. (west of Mts.). Flrs. in cymose umbels. The sta. have curious projecting appendages; in *B. ixioides* S. Wats. (*C. lutea* Lindl. or *flava* Hort.) these are covered with turgid cells, which rupture when touched by any hard body, allowing a honey-like fluid to escape (*Linn. Soc. Journ.* XXX. p. 285).

Bromelia Plum. Bromeliaceae (1). 4 sp. W. Ind. and Brazil.

Bromeliaceae. Monocotyledons (Farinosae). 40 gen. with 400 sp. trop. Am. Many are terrestrial plants (xerophytes, living on rocks &c.), but the bulk of the sp., by virtue of their good seed-distribution and their xerophytic habit, have become epiphytes, forming a very characteristic feature in the vegetation of the forests of the Amazon &c., more so in fact than the orchids, which they surpass in number of individuals though not of sp. Most of them have a very reduced stem, bearing a rosette of fleshy leaves channelled on the upper surface and fitting closely together by their bases, so that the whole plant forms a kind of funnel, which is usually full of water. In this are to be found dead leaves, decaying animal matter and other débris (in Venezuela certain sp. of Utricularia live only in these pitchers). There are a number of adventitious roots which fasten the plant to its support, but which do not aid in its nutrition, or at least very little. The bases of the leaves are covered with peculiar scaly hairs by which the water in the pitcher is absorbed. Water is stored in the leaves, whose bulk consists largely of water-tissue. They have a thick cuticle and often bear scaly hairs that aid in reducing transpiration. Some sp. show a totally different habit to this, *e.g. Tillandsia usneoides* (*q.v.*). [See p. 173 and paper by Schimper there referred to.]

The infl. usually rises out of the centre of the pitcher and has as a rule brightly coloured bracts adding to the conspicuousness of the flrs. Flr. usually ☿, regular, 3-merous. Perianth 3 + 3 or (3) + (3), the outer whorl sepaloid, persistent, the inner petaloid; A 6, introrse, often epipet.; G (3), inf., semi-inf., or sup., 3-loc., with ∞ anatropous ovules on the axile placentae in each. Style 1, with 3 stigmas. Frt. a berry or capsule; seeds in the latter case very light, or winged. Embryo small, in mealy endosperm.

Classification and chief genera (after Wittmack):

1. *Bromelieae* (berry; ovary inf.; leaf with thorny teeth): Bromelia, Ananas, Billbergia, Aechmea.

2. *Pitcairnieae* (capsule; ovary semi-inf. or almost sup.; leaf entire, or toothed at base, rarely at top): Pitcairnia.
3. *Puyeae* (capsule; ovary sup.; leaf thorny; usually large stem): Puya, Dyckia.
4. *Tillandsieae* (do., but leaf entire; seed hairy): Tillandsia.

[Placed in Epigynae by Benth.-Hooker, in Liliiflorae by Eichler (Warming).]

Bromus Dill. Gramineae (X). 45 sp. temp., and trop. Mts. 7 in Brit. (brome-grass). Though so common, they are of no value as pasture grasses.

Brosimum Sw. Moraceae (II). 8 sp. trop. Am. The infl. is remarkable (fig. in *Nat. Pfl.*), consisting of a spherical pseudo-head composed of one ♀ flr. and many ♂ flrs. The former is sunk into the centre of the common receptacle, and its style projects at the top, whilst the latter occupy the whole of the outer surface. Each ♂ flr. has a rudimentary perianth and one sta., whose versatile anther dehisces in a curious way, passing from a shape somewhat like ⫪ to one like ⫫. The achene is embedded in the fleshy receptacle.

The achene of *B. Alicastrum* Sw. is the bread-nut (not to be confused with Artocarpus, the bread-fruit), which is cooked and eaten in the W. Ind., &c. *B. Galactodendron* D. Don. is the cow-tree or milk-tree of Venezuela. When a notch is cut in the stem, the milky latex flows out in considerable quantities; it tastes very like ordinary milk and is used for the same purposes. The wood of several sp. is useful, though liable to split.

Broussonetia L'Hérit. Moraceae (I). 3 sp. E. As. Diœcious; ♂ flrs. in pseudo-racemes, with explosive sta. like those of Urtica (unusual in this order); ♀ flrs. in pseudo-heads. Multiple frt. (cf. Morus &c.). *B. papyrifera* Vent. is the Paper-mulberry of Japan. Paper is made from the inner bark (see *Treas. of Bot.*); in Polynes. the natives make cloth from it (tapa or kapa cloth).

Browallia Linn. Solanaceae (V). 6 sp. trop. Am.

Brownea Jacq. (*Hermesias* Loefl.). Leguminosae (II. 3). 10 sp. trop. Am., W. Ind. The young shoots hang down and their leaves are red (p. 157). The flrs. in some sp. are borne on old wood (p. 156).

Bruckenthalia Reichb. Ericaceae (IV. 9). 1 sp. S. E. Eur.

Brugmansia Blume. Rafflesiaceae. 3 sp. Malay Arch.

do. Pers. = Datura Linn.

Bruguiera Lam. Rhizophoraceae. 5 sp. trop. As., Afr., Austr. One of the trees of the mangrove-formation (p. 191). Like Rhizophora but without the aerial roots from the higher branches. The roots in the mud give off erect aerating branches, as in Sonneratia &c.

Brunella Tourn. = Prunella Linn.

Brunfelsia Plum. Solanaceae (V). 22 sp. trop. Am.

Bruniaceae. Dicotyledons (Archichl. Rosales). 12 gen. with 50 sp. Cape Col. Heath-like shrubs, with alt., exstip. leaves and racemose infl. Flr. ☿, usually regular, 5-merous, generally perigynous. Sta. in one whorl. Cpls. (3—2) each with 3 or 4 ovules, or 1 with 1 ovule. Capsule with 2, or nut with 1, seeds. Aril. Endosperm. Placed in Rosales by Benth.-Hooker. Rarely seen in Eur. [See *Nat. Pfl.*]

Brunonia Sm. Goodeniaceae. 1 sp. Austr., Tasm. It differs from the other G. very much (see order) and is sometimes classed as a separate order.

Brunsvigia Heist. Amaryllidaceae (I). 9 sp. S. Afr.

Brya P. Br. Leguminosae (III. 7). 3 sp. Cent. Am., W. Ind. *B. Ebenus* DC. yields the wood known as Jamaica or American Ebony.

Bryanthus S. G. Gmel. Ericaceae (I. 3). 6 sp. N. W. Am., one of which, *B. taxifolius* A. Gray, is circumpolar (incl. Brit.).

Bryonia Linn. Cucurbitaceae (III). 8 sp. Eur., As., Afr. *B. dioica* Jacq. is our common white bryony, which marks the N. limit of the order in Eur. The ♂ flr. is about twice as large as the ♀. Honey is secreted at the base of the perianth and protected in the male by the bases of the filaments. The flr. is visited in Low Germany chiefly by short tongued bees, and especially by *Andrena florea* F., which appears to confine itself to this plant (Müller). In Britain we have very few of these insects (in proportion), at any rate in the north and in Wales, and it is noteworthy that the bryony does not occur in Scotland and is rare in Wales. It would probably prove of interest to investigate its mechanism and insect-visitors in various parts of England. Being diœcious, it is dependent upon insects for fertilisation, and it is possible that its distribution is largely determined by that of the insects suited to it (cf. Aconitum, Calystegia, &c.).

Bryophyllum Salisb. Crassulaceae. 4 sp. S. Afr., Madag. *B. calycinum* Salisb. in Trop. of both worlds. In the notches on the leaves of this sp. adventitious buds develope, giving rise to new plants (p. 113). In *B. proliferum* Bowie there are simple and compound leaves on the same plant. Calyx and corolla are both gamophyllous.

Buchanania Spreng. Anacardiaceae (I). 20 sp. trop. As.

Buchnera Linn. Scrophulariaceae (III. 11). 30 sp. trop.

Bucklandia R. Br. Hamamelidaceae. 1 sp. *B. populnea* R. Br. Himal. to Java. The large stipules are folded against one another, enclosing and protecting the young axillary bud or infl. The flrs. are in heads, which stand in groups of 4. They are polygamous or monœcious and are sunk in the axis. The "calyx-tube" becomes visible as a ring after flowering. The wood is valued in the arts.

Buda Adans. = Spergularia Presl.

Buddleia Houst. Loganiaceae. 70 sp. trop. and sub-trop. This genus and its allies are sometimes placed in Scrophulariaceae, but possess stipules (though sometimes reduced to mere interpetiolar lines).

Buettneria Loefl. Sterculiaceae. 50 sp. trop.

Bulbine Linn. Liliaceae (III). 24 sp. S. Afr.

Bulbinella Kunth. Liliaceae (III). 13 sp. S. Afr., N. Z., &c.
Bulbocodium Linn. Liliaceae (I). 1 sp. Eur.
Bulbophyllum Thou. Orchidaceae (22). 100 sp. trop. and S. temp. Epiphytes with great reduction of leaf surface. The leaves are often mere scales and the assimilation is performed by the tubers. In *B. minutissimum* F. Muell., and other sp., the tubers are hollow with the stomata on the inner surface (cf. the leaf of Empetrum). For the flr. see Darwin's *Orchids*, p. 137.
Bulliarda DC. = Tillaea Michx.
Bumelia Sw. Sapotaceae (I). 20 sp. Am.
Bunchosia Rich. Malpighiaceae. 30 sp. trop. Am. Like Malpighia.
Bunias (Tourn.) Linn. Cruciferae (IV. 19). 5 sp. Medit., As. In some sp. the frt. is provided with hooks.
Bunium Linn. = Carum L., and Conopodium Koch (in part).
Buphthalmum Linn. Compositae (IV). 4 sp. Eur., As. minor.
Bupleurum (Tourn.) Linn. Umbelliferae (5). 90 sp. Eur., As., Afr., N. Am. 4 Brit. sp. (buplever or hare's ear), of which *B. rotundifolium* L. is most common; it has perfoliate leaves, whence the name throw-wax (thorow-wax) by which it is sometimes known. All sp. have entire leaves, an unusual thing in this order.
Burbidgea Hook. f. Zingiberaceae. 1 sp. Borneo (p. 148). The corolla segments are large, the lateral staminodes absent. The small labellum and petaloid sta. stand up in the centre of the flr.
Burchellia R. Br. Rubiaceae (8). 1 sp. Cape Col.
Burlingtonia Lindl. = Rodriguezia Ruiz et Pav.
Burmanniaceae. Monocotyledons (Microspermae). A small order of tropical forest plants, chiefly "colourless" saprophytes. *Chief genera:* Burmannia, Thismia. (See *Nat. Pfl.*, and *Ann. of Bot.* 1895.)
Bursa Wigg = Capsella Medic.
Bursera 'Jacq.' ex Linn. Burseraceae. 45 sp. trop. Am. *B. gummifera* L. furnishes the resin known as American Elemi.
Burseraceae. Dicotyledons (Archichl. Geraniales). 13 gen. with 300 sp. trop. Shrubs and trees with alt., usually compound, dotted leaves. Balsams and resins occur, in lysigenous or schizogenous passages. Flrs. small, generally unisexual, with disc like Rutaceae, 5- or 4-merous, obdiplostemonous when both whorls of sta. are present. Cpls (5—3). Ovules usually 2 in each. Ovary multiloc. with one style. Drupe or capsule. Seed exalbuminous. Many of the order are useful on account of their resins &c.

Chief genera: Commiphora, Boswellia, Bursera, Canarium. [Placed by Benth.-Hook. in Geraniales, by Warming in Terebinthinae.]
Butea Koen. Leguminosae (III. 10). 4 sp. Ind., China. *B. frondosa* Roxb. is the Dhak or Pulas tree of Bengal, one of the handsomest of trees when in flower. A red juice flows from incisions in the bark; it is known as Bengal Kino and used as an astringent. The flrs. yield an orange-red dye. The tree also yields lac (see *Ficus*).

Butomaceae. Monocotyledons (Helobieae). 4 gen. with 5 sp., trop. and temp. Water and marsh herbs with leaves of various types. Infl. usually a cymose umbel. Flr. ☿, regular, 2- or 3-merous, hypogynous. Perianth 6, in two whorls, the outer sepaloid, the inner petaloid (exc. Butomus). Sta. $9-\infty$, with introrse anthers. Cpls. $6-\infty$, apocarpous, with ∞ anatropous ovules scattered over their inner walls (*cf.* Nymphaea), except on midrib and edges. Follicles; seed ex-albuminous; embryo straight or horse-shoe shaped. The order is united to Alismaceae by Warming, and by Benth.-Hooker. *Chief genera:* Butomus, Hydrocleis.

Butomus Linn. Butomaceae. 1 sp., *B. umbellatus* L., the flowering rush, in temp. As., Eur. (incl. Brit.). The infl. consists of a terminal flr. surrounded by 3 bostryx-cymes.

Butyrospermum Kotschy. Sapotaceae (I). 2 sp. Afr. The oily seeds of *B. Parkii* Kotschy when pressed yield shea butter.

Buxaceae. Dicotyledons (Archichl. Sapindales). 6 gen. with 30 sp. temp. and trop. Evergreen shrubs with exstip. leathery leaves, and no latex. Flrs. in heads or spikes, unisexual, regular, apetalous or naked. Sta. $4-\infty$. $\underline{G}$ usually (3), 3-locular, with 3 styles which are persistent on the fruit. Ovules $2-1$ in each loc., pendulous, anat., with dorsal raphe. Loculicidal capsule, or drupe. Seed with caruncle or none. Endosperm. United to Euphorbiaceae by Benth.-Hooker, but the dorsal raphe places it in Sapindales and it differs in the dehiscence of the fruit; placed in Tricoccae by Eichler (Warming). *Chief genera:* Buxus, Pachysandra.

Buxus Linn. Buxaceae. 19 sp., 8 in Old World, 11 in W. Ind. *B. sempervirens* L. is the box, common in gardens. The flrs. are in heads, a terminal ♀ flr. surrounded by a number of ♂ flrs. The fruit dehisces explosively, the inner layer of the pericarp separating from the outer and shooting out the seeds by folding into a U-shape (*cf.* Viola). The wood of the box is exceedingly firm and close-grained, and is largely used in turning, wood-engraving &c.

Byblis Salisb. Lentibulariaceae (usually in Droseraceae, but *cf.* Lang in *Flora* 88, p. 179). 2 sp. Austr. Insectivorous undershrubs, with stalked and sessile glands like Pinguicula.

Byrsonima Rich. Malpighiaceae. 90 sp. Cent. and S. Am., W. Ind. Fruit a drupe, edible. The bark of some sp. is used in tanning.

Bystropogon L'Hérit. Labiatae (VI. 11). 14 sp. Andes, Canary Is.

Cabomba Aubl. Nymphaeaceae (II). 4 sp. trop. and sub-trop. Am. Water plants with peltate floating leaves and much-divided submerged leaves (see p. 163 and *cf.* Ranunculus, Trapa). The flr. is 3-merous (P $3+3$, A $3-6$, G usually 3) and fully apocarpous (thus forming a link to the other Ranales, with which the gynæceum of most N. does not agree). Fruit of closed follicles. Seed without aril, with endo- and peri-sperm. Ovules sometimes attached to the cpl. *midrib.*

Cabralea A. Juss. Meliaceae. 25 sp. trop. Am.

Cacalia Linn. = Senecio Tourn. (usually same spec. names).

Caccinia Savi. Boraginaceae (IV. I). 7 sp. W. and Cent. As.

Cachrys Linn. Umbelliferae (6). 8 sp. Medit., W. and Cent. As.

Cactaceae. Dicotyledons (Archichl. Opuntiales). 15 gen. with abt. 900 sp. The order is chiefly localised in the dry regions of trop. Am., but it spreads to a considerable distance N. and S. (*Opuntia missouriensis* is found as far as 59° N.). The cacti are able to stand winter frost very well (as the splendid open-air collection at Cambridge testifies) and so are found far up the mountains (to 12000 ft. and even higher). Even in the damp forest regions some sp. appear as epiphytes. The only representative of the order in the Old World is Rhipsalis, found in Afr., Mauritius &c., but several sp. of Opuntia &c. are now naturalised in S. Afr., Austr., &c. and are becoming as troublesome as the thistles of the Pampas or Elodea in Europe.

The C. are xerophytes of the most pronounced type, exhibiting not merely reduction of the transpiring surface, but also storage of water, often in very great quantity. The vegetative organs show great variety of type; the C. afford an interesting case of a family in which the classification is better based upon them than upon the reproductive organs (see below). The root is generally long and well-developed (in cultivation it is liable to decay). The stem is fleshy, of various shapes, rarely bearing green leaves, and usually provided with sharp barbed thorns, which give a most efficient protection against animals. We shall now consider briefly some of the more important types of shoot found in C. (refer to genera for further details). The nearest approach to the ordinary plant-type is found in Pereskia, which has large green leaves, somewhat fleshy, in whose axils are groups of thorns mixed with hairs; the space occupied by these is termed the *areole.* About the morphology of the spines there has been much dispute; most authors regard them as representing the leaves of the axillary shoot, whose stem is undeveloped, but there is also good evidence in favour of the view that they are 'emergences' (p. 114). In some genera they are provided with barbs. The next stage is found in Opuntia, where the stem has taken over the water-storing and assimilating functions, but still bears leaves; in some sp. these aid the stem functions throughout life, but in most they fall off very early, and the stem is usually flattened to expose more surface to air and light. Then we come to Leuchtenbergia, which has an aloe-like habit with the areoles on the tips of the apparent leaves; the flr. arises either in the axil of the 'leaf' or on the areole. Development shows that the apparent leaf is really a compound structure. The bud stands, not exactly in the axil, but on the base of the leaf, and the two grow out together to form a *leaf-cushion* or *mammilla*, at the outer end of which is the growing point and the rest of the leaf itself; the latter is represented by a small scale (often microscopic) and the former gives rise to the thorns &c. on the areole. The same phenomenon is seen in Mammillaria, Cereus sp. &c. In some cases the growing point divides, during the growth of the mammilla, into two, one on the tip, the other in the axil, of the cushion. The latter gives rise to the flr. In Cereus, Echinocactus, &c. the stem is more or less cylindrical, bearing ribs on which are the areoles at regular intervals; the rib is formed by the 'fusion' of mammillae, *i.e.* by the growth of the tissue under them during their development (cf. formation of sympetalous corolla). In Phyllocactus, Epiphyllum, and sp. of Rhipsalis some or all of the shoots exhibit a flattened leafy form with areoles in notches on their edges. This form appears to be derived from the preceding by abortion of some of the ridges, and reversions are often seen (they appear if access of light be prevented). Lastly, other sp. of Rhipsalis show perfectly cylindrical stems.

The bulk of the internal tissue consists of parenchyma in which water is stored; the cell-sap is commonly mucilaginous, thus further obstructing evaporation. The cuticle is thick, and the ridges of the stem are usually occupied by mechanical tissue, whilst the stomata are in the furrows. Everything thus goes to check transpiration to the utmost extent; it is very difficult to dry a cactus for the herbarium, and its vitality is very great. Its growth is slow, but sp. of Cereus &c. reach a great size. Vegetative reproduction is frequent in the mammillate forms, and occurs to some extent in others. In garden practice, cacti are often multiplied by cuttings, for a piece cut off and stuck into the soil will usually grow. Grafting is also largely resorted to.

The flrs. are usually solitary (exc. Pereskia), borne upon or near the areoles or in the axils of mammillae, large and brightly coloured, ☿, regular or zygomorphic. Perianth (∞), showing gradual transition from sepaloid to petaloid leaves, spirally arranged, often up the side of the ovary (cf. Nymphaea). Sta. ∞, epipetalous. $\overline{G}(4-\infty)$, uniloc. with parietal placentae and ∞ anatropous ovules; style simple. Fruit a berry, the flesh derived from the funicles. Endosperm or none.

The fruit of many sp. is edible (*e.g.* Opuntia, &c.). Several sp. are commonly used in making hedges. The Cochineal insect is cultivated on sp. of Nopalea, Opuntia, &c.

Classification and chief genera (after K. Schumann):

I. *CEREOIDEAE* (succulents; leaves reduced to scales, often very minute; no barbed thorns):

1. *Echinocacteae* (flr. funnel- or salver-shaped, in or near the areole): Cereus, Phyllocactus, Epiphyllum, Echinocactus, Melocactus, Leuchtenbergia.
2. *Mammillarieae* (do., but in axil of mammilla): Mammillaria, Pelecyphora.
3. *Rhipsalideae* (flr. rotate): Rhipsalis.

II. *OPUNTIOIDEAE* (succulents with round or flat leaf-like joints; leaves cylindrical, usually falling very early; barbed thorns present; flr. rotate): Opuntia, Nopalea (only genera).

III. *PERESKIOIDEAE* (habit of ordinary plant, with flat leaves and panicles of flrs.; no barbed thorns): Pereskia (only genus).

[Placed in Ficoidales by Benth.-Hook.; Cactiflorae by Warming.]

For further details of this interesting order see genera, and refer to p. 167. See also Goebel, *Pflanzenbiol. Sch.* and *Flora*, 1895, Ganong in *Flora* 1894, and *Bot. Gaz.* 1895, Schumann in *Nat. Pfl.* and Vöchting in *Prings. Jahrb.* 1894. Euphorbia and Stapelia should be carefully compared with the Cactaceae.

Cactiflorae. The 8th cohort of Choripetalae (Eichler, Warming).

Cadaba Forsk. Capparidaceae (III). 14 sp. trop. Afr., As., Austr. The disc is prolonged posteriorly into a long tube, and both androphore and gynophore are present.

Cadia Forsk. Leguminosae (III. 1). 4 sp. trop., E. Afr., Madag., Arabia. Flr. almost regular with free sta.

Caesalpinia Linn. Leguminosae (II. 7). 40 sp. trop. and sub-trop. Some climb by aid of hooks (=mid-ribs of leaves). The pods of *C. Bonducella* Fleming are sometimes brought to Eur. by the Gulf Stream. Those of *C. coriaria* Willd. (divi-divi pods) are imported from S. Am. and W. Ind. for tanning.

Caiophora Presl. = Blumenbachia Schrad.

Cajanus DC. Leguminosae (III. 10). 1 sp. trop. Afr., As., cultivated in warm countries for its seeds, used like peas. It is known as Dhal in India, pigeon-pea in W. Ind.

Cakile Linn. Cruciferae (II. 8). 4 sp. Eur., Medit., N. Am., W. Ind. *C. maritima* Scop., the sea-rocket, in Brit. It has fleshy leaves (p. 186).

Caladenia R. Br. Orchidaceae (4). 30 sp. Austr., N. Z. The labellum in some sp. is irritable (cf. Pterostylis, and see Darwin, *Orchids*, p. 90).

Caladium Vent. Araceae (VI). 10 sp. trop. S. Am., often cultivated for their large variegated leaves.

Calamagrostis Adans. Gramineae (VIII). 130 sp. temp., 3 in Brit.

Calamintha (Tourn.) Lam. Labiatae (VI. 11). 40 sp. N. temp., 3 in Brit. (basil, calamint). Flrs. often gynodiœcious.

Calamus Linn. Palmae (III). 200 sp. trop. As., Afr., Austr. They are mostly leaf-climbers with thin reedy stems. In some sp. there are hooks on the back of the mid-rib, but the more common type of leaf is one in which the pinnae at the outer end of the leaf are represented by stout spines pointing backwards (cf. Desmoncus). The leaf shoots almost vertically out of the bud up among the surrounding vegetation, and the hooks take hold. The stem often grows to immense lengths (500—600 ft.); the plants are very troublesome in tropical forests because the hooks catch in clothes &c. The stripped stems are largely used, under the name of rattan canes, for making chair bottoms, baskets, cables, &c.

Calandrinia H. B. et K. Portulacaceae. 80 sp. Chili to Vancouver, and Austr. The flrs. close very quickly in absence of sunlight.

Calanthe R. Br. Orchidaceae (15). 40 sp. trop. There are 8 pollinia, which, if removed and re-introduced, strike the sloping sides of the rostellum and diverge into the stigmas.

Calathea G. F. W. Mey. Marantaceae. 60 sp. trop. Am., and 2 W. Afr. The staminode β (see order) is present in most sp.

Calceolaria Linn. Scrophulariaceae (II. 4). 130 sp. S. Am., Mexico, N. Z. Many forms and hybrids are cultivated.

Caldesia Parl. = Alisma Linn.

Calea Linn. Compositae (V). 65 sp. Am.

Calendula Linn. Compositae (IX). 15 sp. Medit. *C. officinalis* L. is commonly cultivated in gardens under the name marigold. An interesting "hen-and-chickens" variety is sometimes seen, in which each principal head is surrounded by a number of others, springing from the axils of the involucral bracts. The disc florets are ♂, the ray florets ♀. Three kinds of fruit occur on the head; many biological meanings have been forced into this fact, but in reality nothing is known as to its significance.

Caliphruria Herb. Amaryllidaceae (I). 4 sp. S. Am. Sta. with stipular appendages (see order).

Calla Linn. Araceae (III). 1 sp., *C. palustris* L., in N. Eur. Flrs. ☿ with perianth, borne once in two years. For *C. aethiopica* L. see Richardia.

Calliandra Benth. Leguminosae (I. 1). 100 sp. trop. and sub-trop. Am., As.

Callicarpa Linn. Verbenaceae (IV). 30 sp. trop. and sub-trop.

Callicoma Andr. Cunoniaceae. 2 sp. E. Austr.

Calligonum Linn. Polygonaceae (II. 3). 20 sp. N. Afr., W. As., Steppe plants.

Callipeltis Stev. Rubiaceae (II. 21). 3 sp. Medit.

Calliprora Lindl. = Brodiaea Sm.

Callirhoe Nutt. Malvaceae (II). 7 sp. N. Am., often placed in Malva.

Callistachys Vent. = Oxylobium Andr.

Callistemon R. Br. Myrtaceae (II. 2). 11 sp. Austr., often cultivated as greenhouse shrubs ('bottle-brushes'). The axis of the infl. grows on beyond the flrs. and continues to produce leaves (cf. Eucomis). The sta. form the conspicuous part of the flr., as is often the case in plants of the dry climate of Austr. (cf. Acacia &c.).

Callistephus Cass. Compositae (III). 1 sp. China, Japan, largely cultivated in many varieties under the name China aster.

Callitrichaceae. Dicotyledons (Archichl. Geraniales). Only genus Callitriche (*q.v.*). As usual in such cases of water-plants (see p. 158 and Ceratophyllaceae) the systematic position is doubtful. Benth.-

Hooker unite C. with Haloragidaceae, but the differences between the two are considerable. They have also been placed near Caryophyllaceae, Verbenaceae, Boraginaceae, &c., but seem on the whole nearest to Euphorbiaceae, where they are placed by Engler and by Eichler and Warming (Tricoccae).

Callitriche Linn. Callitrichaceae. 25 sp. (probably only varieties of 1 or 2), cosmop. (exc. S. Afr.). Several forms of water star-wort are common in Brit. The submerged leaves are longer and narrower than the floating, and the more so the deeper they are below the surface. Land forms also occur. Flr. unisexual, naked, commonly with 2 horn-like bracteoles, protogynous; ♂ of 1 sta.; ♀ of (2) cpls., transversely placed, 4-loc. by 'false' septum (cf. Labiatae), with 2 styles. 1 ovule in each loc., pendulous, anatropous with ventral raphe. Schizocarp. Seed with fleshy endosperm. The modes of fertilisation of the flrs. are not very clearly made out.

Callitris Vent. Coniferae (Arauc. 2 a; see C. for genus characters). 15 sp. Afr., Madag., Austr., New Caled. Leaves and cone-scales in whorls. The cone ripens in 1 or 2 years. *C. quadrivalvis* Vent. (N. Afr.) yields Arar wood and Sandarach resin or pounce.

Calluna Salisb. Ericaceae (IV. 9). 1 sp., *C. vulgaris* Salisb., the heather or ling, widely distributed over Eur. and found in Greenland, and from Newfoundland to Massachusetts (the only representative of Ericoideae in Am.). It covers large areas in these regions, together with sp. of Erica and Vaccinium. It is a low evergreen shrub, with linear closely crowded wiry leaves and racemes of flrs. The calyx is coloured like the corolla and the latter is almost polypetalous. The honey is much more easily accessible than in Erica and there is a larger circle of visiting insects, including however many bees (heather honey is the most valuable of all kinds). The stigma projects beyond the mouth of the flr.; insects touch it first and in probing for honey jostle the anthers. The flr. is also wind fertilised; the loose powdery pollen blows about very easily and the stigma is not covered by the corolla.

Calochilus R. Br. Orchidaceae (4). 3 sp. E. Austr.

Calochortus Pursh. Liliaceae (V). 30 sp. W. N. Am.

Calodendron Thunb. Rutaceae (IV). 1 sp. S. Afr.

Calonyction Choisy. = Ipomaea Linn.

Calophaca Fisch. Leguminosae (III. 6). 10 sp. S. Russia to Burmah.

Calophanes D. Don. Acanthaceae (IV. A). 40 sp. trop.

Calophyllum Linn. Guttiferae (III). 55 sp. trop., chiefly Old World. *C. Tacamahaca* Willd. and other sp. yield resins known as Tacamahac. [See Populus.]

Calopogon R. Br. Orchidaceae (14). 4 sp. U. S.

Calothamnus Labill. Myrtaceae (II. 2). 23 sp. W. Austr. The axis goes on bearing leaves beyond the flrs. (cf. Callistemon). Sta. in bundles before the petals, the common axis of the bundle very large.

Calotropis R. Br. Asclepiadaceae (II. 2). 3 sp. trop. As., Afr.

Caltha (Rupp.) Linn. Ranunculaceae (2). 16 sp. temp. *C. palustris* L., in Brit., is the marsh-marigold or king-cup. Honey is secreted by the cpls., and the flrs. have no 'honey leaves,' the calyx being coloured.

Calycanthaceae. Dicotyledons (Archichl. Ranales). 2 gen. with few sp. N. Am. and China. Shrubs, usually aromatic, with opp., simple leaves and terminal acyclic flrs. on short shoots. Perianth ∞, perigynous, spiral, showing gradual transition from sepaloid to petaloid leaves. Sta. 5—30. Cpls. ∞, in hollowed axis; 2 anatropous ovules in each. Achenes enclosed in axis. Embryo large with spirally wound cotyledons, in slight endosperm. *Genera:* Calycanthus, Chimonanthus. [Placed in Ranales by Benth.-Hooker, in Polycarpicae by Warming.]

Calycanthus Linn. Calycanthaceae. 3 sp. N. Am. *C. floridus* L. is the Carolina allspice, a favourite garden shrub.

Calycera Cav. Calyceraceae. 10 sp. S. Am.

Calyceraceae Dicotyledons (Sympet. Campanulatae). 3 gen. with 23 sp., S. Am. Closely allied to Compositae. Herbs with alt. exstip. leaves. Flrs. in heads with involucre of bracts, ☿ or ♂ ♀, epigynous, 4—6-merous. Calyx leafy. Filaments of sta. united, anthers free or slightly coherent at base. Ovary 1-loc.; ovule 1, pendulous, anatropous; stigma capitate. Embryo straight in slight endosperm. *Genera:* Boopis, Calycera, Acicarpha. [Placed in Asterales by Benth.-Hooker, in Dipsacales by Warming.]

Calyciflorae (Benth.-Hooker). The 3rd series of Polypetalae (p. 133).

Calycinae (Benth.-Hooker). The 4th series of Monocotyledons (p. 136).

Calypso Salisb. Orchidaceae (8). 1 sp. cold N. temp.

Calyptranthes Sw. Myrtaceae (1). 70 sp. trop. Am.

Calyptrocalyx Blume. Palmae (IV. 6). 2 sp. Austr., Moluccas.

Calystegia R. Br. Convolvulaceae (I. 4). 7 sp. temp. and sub-trop. 2 in Brit., *C. Soldanella* R. Br. on the coasts, and *C. sepium* R. Br., the large convolvulus of our hedges. The fertilisation of this sp. depends largely on the visits of a particular hawk-moth (*Sphinx convolvuli*) and the distribution areas of the two correspond to some extent (cf. Aconitum). Often united to Convolvulus (*q.v.*).

Camassia Lindl. Liliaceae (V). 2 sp. N. Am. (Quamash).

Camelina Crantz. Cruciferae (IV. 14). 8 sp. Eur., Medit. (1 Brit.).

Camellia Linn. Theaceae. 8 sp. Ind., China, Japan. *C. japonica* L. and others are largely cultivated, and many varieties and double-flowered forms exist. The genus is often united to Thea (*q.v.*). *C. Thea* Link., *C. viridis* Link., and *C. Bohea* Lindl. = *T. sinensis* L.

Camoensia Welw. Leguminosae (III. 1). 2 sp. W. trop. Afr.

Campanales (Benth.-Hooker). The 3rd cohort of Gamopetalae (p. 134).

Campanula (Tourn.) Linn. Campanulaceae (I. 1). Abt. 240 sp. N. temp., chiefly Medit. 8 in Brit. The commonest sp. is *C. rotundifolia* L., the blue-bell of Scotland (in England the hare-bell). The pollen is shed in the bud, the sta. standing closely round the style and depositing their pollen upon the hairs. As the flr. opens the sta. wither, with the exception of their triangular bases that protect the honey, and the style presents the pollen to insects visiting the flr. After a time the stigmas separate and the flr. is now female, and finally the stigmas curl right back on themselves and so effect self-fertilisation. (See order, and cf. Phyteuma and Jasione.) The seeds are light and are contained in a capsule, which if erect dehisces at the apex, if pendulous at the base, so that the seeds, as is so often the case (cf. Papaver), can only escape when the plant is shaken, *e.g.* in strong winds. Several sp. are cultivated (Canterbury bells &c.).

Campanulaceae. Dicotyledons (Sympet. Campanulatae). 59 gen. with abt. 1000 sp., temp. and sub-trop. They are mostly perennial herbs (a few trees and shrubs), with alt., exstip. leaves, and usually with latex. The infl. may terminate the primary axis, or one of the second order. It is generally racemose, ending with a terminal flr. in Campanuloideae. In some cases, instead of single flrs. in the axils of the bracts of the raceme, small dichasia occur (cf. Labiatae). Others have the whole infl. cymose (Canarina, Pentaphragma &c.).

The flr. is usually ☿, regular or zygomorphic, epigynous, generally 5-merous. The odd sepal is posterior in Campanuloideae, but anterior in the other groups. In these, however, a twisting of the axis through 180° takes place before the flr. opens (cf. Orchids), so that the odd sepal is finally posterior. K 5, open; C (5) valvate; A 5 epigynous; anthers introrse, sometimes united; $\overline{G}$ (5), (3) or (2), multiloc. with axile placentae bearing ∞ anatropous ovules. Style simple; stigmas as many as cpls. Fruit a capsule, dehiscing in various ways in different genera, or a berry. Seeds with fleshy endosperm.

The natural history of the flr. in this order is of interest, both in itself and as exhibiting transitions to the Composite type. Honey is secreted by a disc at the base of the style and is covered in most cases by the triangular bases of the sta., which fit closely together and only allow of the insertion of a proboscis between them. This, taken together with the size of the flrs., their frequently blue colour and pendulous position, points to their being best adapted to the visits of bees. Observation shows this to be the case, but there are also many other visitors of various insect classes, so that this order cannot be placed in the flower class H (see p. 90) but must be placed in class B. A few exceptions occur however; the bulk of the order has large flrs., conspicuous by themselves, but Phyteuma and Jasione have small flrs. massed together in heads, and therefore come into class B′ along with the Compositae.

The general principle of the floral mechanism is the same throughout the order (so far as is known) and agrees with that of the Compositae. The flr. is very protandrous, and the style (with its stigmas closed up against one another) has the pollen shed upon it by the anthers, either in the bud or later. Usually there is a bunch of hairs upon the style to hold the pollen. For some time the style acts as pollen-presenter to insects visiting the flr.; after a time the stigmas separate and the female stage sets in, and finally, in many cases the stigmas curl back so far that they touch the pollen still clinging to their own style, and thus effect self-fertilisation, so that seed is sure to be set one way or other. For details see genera, especially Campanula, Phyteuma, Jasione, Lobelia, and cf. Compositae.

Classification and chief genera (after Schönland):

I. *CAMPANULOIDEAE* (flr. actinomorphic, rarely slightly zygomorphic; anthers usually free):

1. *Campanuleae* (cor. valvate; flr. symmetrical): Campanula, Phyteuma, Wahlenbergia, Platycodon, Jasione.
2. *Pentaphragmeae* (cor. valvate; flrs. asymmetric, in cincinni): Pentaphragma (only genus).
3. *Sphenocleae* (cor. imbricate): Sphenoclea (only genus).

II. *CYPHIOIDEAE* (flr. zygomorphic; sta. sometimes united; anthers free): Cyphia, Nemacladus.

III. *LOBELIOIDEAE* (flr. zygomorphic, rarely almost actinomorphic; anthers united): Centropogon, Siphocampylus, Lobelia.

Campanulatae. The 9th cohort of Dicotyledons (Sympet.) See p. 132.

Campanulinae (Warming). The 10th cohort of Sympetalae (p. 138).

Camphora (Bauh.) Linn. = Cinnamomum Tourn.

Campsidium Seem. = Tecoma Juss.

Camptosema Hook. et Arn. Leguminosae (III. 10). 12 sp. S. Am.

Campylobotrys Lem. = Hoffmannia Sw.

Campynema Labill. Amaryllidaceae (IV). 2 sp. Austr., Tasm. See order.

Cananga Hook. f. et Thoms. Anonaceae (3). 3 sp. trop., E. As. to Austr. *C. odorata* Hook. f. is cultivated for its flrs. which yield the perfume known as Ylang-ylang or Macassar oil.

Canarina Linn. Campanulaceae (I. 1). 3 sp. Canary Is., trop. Afr., Moluccas. Like Campanula, but usually 6-merous, and with edible berry fruit.

Canarium (Rumph.) Linn. Burseraceae. 80 sp. trop. As., Afr. "*C. commune* L. is said to furnish the resin known as Manilla Elemi" (see Bursera). *C. strictum* Roxb. (Malabar) yields black dammar (see Agathis).

Candollea Labill. in Ann. Mus. Par. 1805 (= *Stylidium* Sw.; for *C.* of Labill. in Nov. Holl. Pl. 1806, see Hibbertia). Candolleaceae. 85 sp. Austr., N.Z., E. As. *C. adnata* F. Muell. is often found in greenhouses. It has an irritable gynostemium. Upon the smallest of the corolla segments is a swollen nectary. In the newly opened flr. the gynostemium stands erect. Then it bends downwards till it lies upon the nectary, and the anthers dehisce; the stigma faces upwards. The tension of the tissues (the phenomenon is a case of strongly marked nutation) now changes sides, but the gynostemium is prevented from moving by the sticky nectary, until a considerable strain is set up. In this condition a slight touch, *e.g.* by an insect, suffices to free it and it springs violently over, striking the visitor with the stigma and also throwing over it a shower of pollen. The periodic movements go on for some time and may be compared to those of the leaflets of Desmodium.

Candolleaceae (*Stylidiaceae*). Dicotyledons (Sympet. Campanulatae). 3 gen. with 100 sp. Austr., N. Z., trop. As., S. Am. Small herbs or undershrubs, more or less xerophytic, without latex. Leaves simple, exstip. Flrs. in racemes or cymes, ☿ or unisexual, usually zygomorphic. K 5 or (5), the odd sepal posterior; C (5), the anterior petal (*labellum*) often different from the rest. Of the 5 sta. only the 2 posterior lateral ones are developed and these are united with the style to form a gynostemium (cf. Orchids, Asclepiads &c.); anthers extrorse. $\overline{G}$ (2), usually 2-loc., but occasionally the posterior loc. is aborted. Fruit a capsule. Seed with fleshy endosperm. *Genera:* Phyllachne, Levenhookia, Candollea. [Placed in Campanales by Benth.-Hooker, in Campanulinae by Warming.]

Canella P. Br. (*Winterana* L.). 2 sp. W. Ind., trop. Am. *C. alba* Murr. yields Canella bark, used as a tonic and stimulant.

Canellaceae (*Winteranaceae*). Dicotyledons (Archichl. Parietales). 4 gen. with 7 sp. "One of the best examples of discontinuous distribution of old families (p. 146). 2 gen. with a few sp. in S. Am. and W. Ind., 1 (monotypic) in Madag. and 1 (also monotypic) in E. Afr." (Warburg). Trees with alt., leathery, entire, exstip., gland-dotted leaves. Flrs. solitary or in racemes or cymes, ☿, regular, K 3, imbricate; C 4—12 free or united; A ∞, hypogynous, completely united into a tube, with extrorse anthers; $\underline{G}$ (2—6), 1 loc., with 2-∞ semi-anatropous ovules on each parietal placenta. Berry. Embryo straight or slightly curved in rich endosperm. *Genera:* Canella, Cinnamodendron, Warburgia, Cinnamosma. [Placed in Parietales by Benth.-Hooker, in Cistiflorae by Eichler.]

Canna Linn. Cannaceae. Over 40 sp. trop. and sub-trop. Am. Several are in cultivation for their handsome flrs., *e.g.* *C. indica* L. (Indian shot). The habit is like that of Zingiberaceae or Marantaceae, but C. can be distinguished even when not in flr. by their possessing neither the ligule of the former nor the pulvinus of the latter. The infl. is terminal, and usually composed of 2-flowered cincinni. The two flrs. are homodromous, but the bracteole is to the right in one and to the left in the other (behind one or other of the two lateral sepals in the diagram). Flr. ☿, asymmetric, epigynous. K 3, C (3). The andrœceum is the most conspicuous part of the flr. There is a leafy sta. bearing half an anther on one edge, and a number of petaloid structures round it, usually 3 but sometimes 1 or 4. One of these is the labellum (not equivalent to that of

Zingiberaceae), and is rolled back on itself outwards. The other two are often termed the wings (α β in diagram). When a fourth staminode (γ, cf. Marantaceae) is present it stands behind the fertile sta. Other sp. have only the labellum. The ovary is inferior, of 3 cpls. with a petaloid style, 3-loc.; ovules in 2 rows in each loc., anatropous. Fruit a capsule, usually warty. Seed with perisperm and straight embryo.

Floral diagram of *Canna indica* (after Eichler). The bracteole is omitted. S = petaloid style; L = labellum; α β = staminodes.

As to the morphological explanation of the andrœceum, there are two views. Eichler (*Blütendiag.* I. p. 174) regards the labellum as a lateral sta. of the inner whorl, and the fertile sta. together with all the staminodes as the posterior sta. of the same whorl; the other sta. of the inner, and all the sta. of the outer, whorl are wanting. The older view looks upon β, γ, as the 2 posterior sta. of the outer whorl, and the labellum, α, and the fertile sta. as the 3 sta. of the inner whorl. [Cf. this flr. with those of Musaceae, Zingiberaceae and Marantaceae.]

The pollen is shed upon the style in the bud; insects alight on the labellum, touch first the terminal stigma and then the pollen. The rhizome of *C. edulis* Ker-Gawl. is edible, containing large quantities of starch.

Cannabaceae (Warming) = § IV of Moraceae (*q.v.*).

Cannabis (Tourn.) Linn. Moraceae (IV). 1 sp. Cent. As., *C. sativa* L., the Hemp. Infl. like that of Humulus ♂, diœcious. The hemp is largely cultivated. A valuable fibre, used for ropes &c., is obtained from the stem in the same way as flax is prepared from Linum (*q.v.*). In trop. countries, especially India, the plant is cultivated for its narcotic resin (Churrus). This exudes from the leaves and is collected by men brushing through the plants in leathern dresses to which it adheres. The Asiatics are much addicted to the use of hemp as a narcotic; the dried leaves (Gunjah, Hashish, or Bhang) are smoked with or without tobacco, or pounded with water as a drink, and have an intoxicating stimulant effect; the resin is more powerful in its action. "In small quantities it produces pleasant excitement, which passes into delirium and catalepsy if the quantity be increased." For details see *Treas. of Bot.*

Cannaceae. Monocotyledons (Scitamineae). Only genus Canna (*q.v.*). Often united to Marantaceae.

Canscora Lam. Gentianaceae (I. 2). 14 sp. Indo-mal., trop. Afr., Austr.

Canthium Lam. = Plectronia Linn.

Cantua Juss. Polemoniaceae. 7 sp. Peru, Bolivia.

Capparidaceae. Dicotyledons (Archichl. Rhœadales). 35 gen. with 300 sp., trop. and warm temp. Many are xerophytes, with reduced, often with inrolled, leaves (cf. Empetrum). Herbs or shrubs, with alt. simple or palmate leaves, often with stipules (these are frequently represented by thorns or glands). Flrs. ☿, regular, usually in racemes, bracteate but without bracteoles. The perianth resembles that of Cruciferae (K 2 + 2, C 4 diagonal), but great variety occurs in the andrœceum. In some sp. of Cleome there are 4 sta. in two whorls, but elsewhere there are more. Some sp. of Cleome &c. show tetradynamous sta. In others, still further branching of the median sta. occurs and usually the posterior sta. is more branched than the anterior. Staminody of some of the branches is frequent. Cpls. typically (2), transverse as in Cruciferae, with parietal placentae but without a replum. In many sp. of sub-order III the number rises to 10 or 12 by the addition of a second whorl of cpls. and by dédoublement. Ovules ∞, campylotropous.

A further complication is introduced by the presence of axial effigurations &c. in the flrs. Thus a disc may occur between perianth and sta. (usually thicker at the posterior side), or a gynophore between sta. and ovary, or both may occur. Or the disc may grow up in the centre to form an androphore on which the sta. are borne and above them there may be a gynophore also. From the disc there often grow out structures of various shapes and sizes; these may be scales quite free from one another, or, as in Cadaba &c., may be united into a tubular structure. Or the scales may, as in Steriphoma &c., alternate with and be joined to the sepals.

The fruit is a siliqua (with replum), nut, berry or drupe. Seed exalbuminous with embryo folded in various ways as in Cruciferae. The floral mechanisms are much in want of study. Few of the order are useful: see Capparis &c. For further details see Pax in *Nat. Pfl.* from which the above account is condensed.

Classification and chief genera (after Pax):

A. Glandular annuals. Siliqua with replum.

I. *CLEOMOIDEAE*: Cleome, Polanisia.

B. Mostly shrubs, with hairs or scales, rarely glandular. No replum.

II. *DIPTERYGIOIDEAE* (samara): Dipterygium (only genus).

III. *CAPPARIDOIDEAE* (berry): Capparis, Cadaba, Maerua.

IV. *ROYDSIOIDEAE* (drupe): Roydsia.

C. Prostrate undershrubs. Calyx tube present. Petals (2). Nut.

V. *EMBLINGIOIDEAE*: Emblingia (only genus).

[Placed in Parietales by Benth.-Hooker, Rhœadinae by Warming.]

Capparis (Tourn.) Linn. Capparidaceae (III). 150 sp. trop. and subtrop. (exc. N. Am.). Many sp. climb by aid of recurved stipular thorns. The flr.-buds of *C. spinosa* L. (Medit.) are well known as capers (cf. Eugenia).

Capraria (Tourn.) Linn. Scrophulariaceae (III. 10). 4 sp. trop. and sub-trop. Am.

Caprificus Gasp. = Ficus Tourn.

Caprifoliaceae. Dicotyledons (Sympet. Rubiales). 11 gen. with 230 sp. temp. (chiefly N.) and on trop. Mts. Mostly trees and shrubs with decussate usually exstip. leaves (see Sambucus). Flrs. ☿, regular or zygomorphic, in cymes, usually 5-merous with the odd sepal posterior. Sta. in one whorl, epipetalous. $\overline{G}$ (2—5), multiloc. with 1—∞ pendulous ovules in each loc. Fruit usually a berry or drupe (capsule in Diervilla). Embryo small in fleshy endosperm.

Classification and genera (after Fritsch): The C. were separated from Rubiaceae, before the tropical forms of R. were well known, chiefly on the ground of their different habit and their want of stipules. The former distinction only divides the C. from the European R. and the latter is vitiated by the fact that Sambucus possesses stipules. It has lately been proposed to split off this genus (*q.v.*) as an independent order, and to unite the remaining C. to Rubiaceae. The genus Adoxa, placed in C. by Benth.-Hooker, is now erected into an independent order Adoxaceae (*q.v.*).

1. *Sambuceae* (leaf pinnate; anthers extrorse): Sambucus.

2. *Viburneae* (leaf simple or lobed; anther introrse; all loc. 1-ovuled): Viburnum, Triosteum.

3. *Linnaeeae* (do., but 2 loc. many-ovuled): Symphoricarpus, Abelia, Dipelta, Linnaea.

4. *Lonicereae* (do. but all loc. many-ovuled): Alseuosmia, Lonicera, Diervilla, Leycesteria.

[Placed in Rubiales by Benth.-Hooker and Warming.]

Caprifolium Tourn. ex Linn. = Lonicera Linn.

Capsella Medic. Cruciferae (IV. 14). 4 sp. N. temp. *C. Bursa-pastoris* Medic. (shepherd's purse) abounds in Brit. and is established as a weed all over the world. The small flrs. fertilise themselves. In early spring and late autumn the sta. are often more or less aborted. The leaves vary much in shape and degree of division in various situations.

Capsicum (Tourn.) Linn. Solanaceae (II. 4). 30 sp. Cent. and S. Am., 1 in Japan. *C. annuum* L. is largely cultivated. Its fruits are the familiar chillies or red peppers; when dried and ground they form Cayenne pepper. Other sp. are used in the same way.

Caragana Lam. Leguminosae (III. 6). 20 sp. mid-As., China.

Caraguata (Plum.) Lindl. Bromeliaceae (4). 12 sp. Colombia. Epiphytes.

Caraipa Aubl. Guttiferae (I). 8 sp. trop. S. Am. They yield valuable timber and balsam of Tamacoari, used in curing the itch. [Ternstroemiaceae Benth.-Hooker.]

Cardamine (Tourn.) Linn. (incl. *Dentaria* Linn.). Cruciferae (II. 11). 70 sp., chiefly temp. *C. pratensis* L. (cuckoo-flower) and others in Brit. *C. impatiens* L. has an explosive fruit like that of Eschscholtzia. *C. chenopodiifolia* Pers. (S. Am.) possesses two kinds of fruit. Those formed on the upper part of the plant are normal siliquae; at the base, in the axils of the leaves of the rosette cleistogamic flrs. are formed which burrow into the soil and produce fruit there (cf. Arachis, Trifolium, &c.). In *C. pratensis* there is extensive vegetative reproduction by the formation of adventitious buds on the radical leaves (p. 113) and in *C.* (*D.*) *bulbifera* R. Br. by means of axillary bulbils.

Cardiospermum Linn. Sapindaceae (I). 11 sp. trop., esp. Am.

Carduus (Tourn.) Linn. *Synonymy: C. acaulis* Linn., *arvensis* Robs., *ferox* Vill., *heterophyllus* Linn., *lanceolatus* Linn., *montanus* Pers., *palustris* Linn., *pratensis* Huds. = Cnicus (same sp. names); *C. Marianus* Linn. = Silybum M.; *C. mollis* Linn. = Jurinea m.; *C. tuberosus* L. = Cnicus pratensis. The genera Carduus, Cnicus and Cirsium are very nearly allied, and scarcely any two floras agree in the sp. assigned to them. See *Index Kewensis*.

Compositae (XI). 80 sp. Eur., N. Afr., As. (thistles). *C. nutans* L. and others in Brit.

Carex (Dill.) Linn. Cyperaceae (II). Over 500 sp. N. and S. temp., in marshes, &c. About 60 in Brit. (sedges). Grass-like plants. Pseudo-spikelets 1-flowered, arranged in long spikes, which are sometimes unisexual, sometimes with both ♂ and ♀ flrs. The ♀ flr. has a second glume (see order). The flrs. are protogynous and wind-fertilised. There is considerable vegetative reproduction by offshoots. Many of the Brit. sp. are alpine plants; others, *e.g. C. arenaria* L. grow on sand-dunes and have the habit of Ammophila (p. 186).

Carica Linn. Caricaceae. 24 sp. trop. and sub-trop. Am. *C. Papaya* L., (Papaw) largely cult. for its edible fruit. The leaves, &c., contain the proteid-ferment papaïn. Meat rubbed with them becomes tender through partial digestion of the fibres. See Solms in *Bot. Zeit.* 1889.

Caricaceae (*Papayaceae* Warming). Dicotyledons (Archichl. Parietales). 2 gen. (Carica, Jacaratia) with 30 sp. neotrop., S. Am. Flrs. ♂, ♀, 5-merous, hypog., sympet. A 5 + 5, G 1- or 5-loc. Ovules ∞, anat. Berry. Endosperm. United to Passifloraceae by Benth.-Hooker; placed in Passiflorinae by Warming.

Carissa Linn. (*Arduina* Mill.). Apocynaceae (I. 1). 20 sp. W. Afr. to Austr. Shrubs with branch thorns.

Carlina Linn. Compositae (XI). 17 sp. Eur., and Canary Is. to mid-As. *C. vulgaris* L. (carline-thistle) is common in Brit. *C. acaulis* L. is the weather-thistle of the Alps, &c. The outer bracts of the involucre are prickly, the inner membranous and shining. They spread out like a star in dry air, but in damp weather bend inwards over the fruit-head.

Carludovica Ruiz et Pav. Cyclanthaceae. 40 sp. trop. Am. The habit is that of a small palm (a few are climbers), with short stem and fan leaves, in whose axils arise the infls. Each is a cylindrical spadix, enclosed at first in a number of bracts, which fall off and leave it naked. Its surface is covered with flrs. arranged as in the diagram (after Drude in *Nat. Pfl.*; F = ♀, m = ♂, flr.). The ♂ flr. has a rudimentary perianth, and ∞ sta., united below. The ♀ is sunk in and united with the tissue of the spadix. It has 4 very long staminodes and 4 stigmas corresponding to the 4 placentae in the 1-loc. ovary.

	m						m	
m		m		F		m		m
	m			m			m	
	F		m		m		F	
	m			m			m	
m		m		F		m		m
	m						m	

When the spadix opens the ♀ flrs. are ripe and the long staminodes give a tangled appearance to the whole. After a few days the stigmas cease to be receptive and the anthers open. Afterwards the ♂ flrs. drop off and a multiple fruit is formed, composed of berries.

The leaves of *C. palmata* R. & P., gathered young, cut into thin strips and bleached, form the material of which Panama hats are made.

Carmichaelia R. Br. Leguminosae (III. 6). 12 sp. N. Z. (1 on Lord Howe's I.). Xerophytes with flattened green stems (phylloclades, see p. 166) and no green leaves (cf. Bossiaea).

Carpenteria Torr. Saxifragaceae (III). 1 sp. Calif. Like Philadelphus, but ovary superior.

Carpesium Linn. Compositae (IV). 8 sp. S. Eur., As.

Carpinus Linn. Betulaceae. 12 sp. N. temp. *C. Betulus* L. in Brit. (the hornbeam). The ♀ catkins are terminal on long shoots, the ♂ are themselves short shoots. In the axil of each scale of the latter are 4—10 sta. each split almost to the base. No bracteoles are present, so that it is doubtful how many flrs. of the possible 3 (see order) are represented. In the ♀ there are the 2 lateral flrs. with all 6 bracteoles. On the top of the 2-loc. ovary is a small perianth. The fruit is a 1-seeded nut with a 3-lobed leafy wing on one side, whose centre lobe corresponds to the bract α or β, the lateral lobes to the bracteoles α', β'; these unite and grow large after fertilisation. The hornbeam is very like the beech in habit, but the leaves are not shiny. The timber is not much used.

Carrichtera Adans. Cruciferae (II. 9). 1 sp. Medit.

Carthamus (Tourn.) Linn. Compositae (XI). 20 sp. Medit., Afr., As. *C. tinctorius* L. is the safflower, largely cultivated in Asia &c.; its flrs. are used in dyeing; powdered and mixed with talc they form rouge.

Carum Linn. (incl. *Bunium* Linn., *Petroselinum* Hoffm.). Umbelliferae (5). 60 sp. temp. and sub-trop. *C. Carvi* L. is cultivated for its fruits (caraway seeds). *C. Petroselinum* Benth. and Hook. f. (*P. sativum* Hoffm.) is the common parsley.

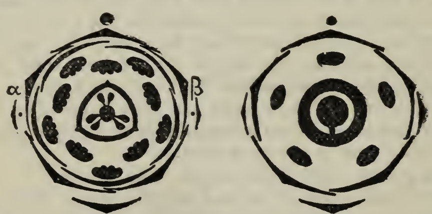
Carya Nutt. Juglandaceae. 10 sp. N. Am., the hickory trees, cultivated for their wood, which is very tough and elastic, and for the edible fruit (like walnuts).

Caryocar Linn. Caryocaraceae. 10 sp. trop. Am. The wood is very durable and is used in ship-building. The fruit is a large 4-seeded drupe; the seeds are the Souari- or Butter-nuts of commerce.

Caryocaraceae (*Rhizoboleae*). Dicotyledons (Archichl. Parietales). 2 gen. with 13 sp. trop. Am. Trees and shrubs with ternate opp. or alt. leaves with deciduous stipules. Flrs. ☿ in racemes. K (5—6), C (5—6), A ∞, united into a ring or in 5 bundles. Ovary free, superior, 4- or 8—20-loc. with as many styles. 1 ovule in each loc. Fruit usually a drupe with oily mesocarp, and woody endocarp which splits into 4 mericarps; sometimes a leathery schizocarp. Little or no endosperm. *Genera:* Anthodiscus, Caryocar. Placed in Ternstrœmiaceae by Benth.-Hooker.

Caryophyllaceae (incl. *Illecebraceae* or *Paronychiaceae*, and *Scleranthaceae*). Dicotyledons (Archichl. Centrospermae). About 60 gen. with 1300 sp. cosmop. Many in Brit. Most are herbs, a few undershrubs, with opposite simple usually entire leaves, often stipulate; the stem often swollen at the nodes, the branching dichasial. The infl. usually terminates the main axis and is typically a dichasial cyme, but both in the vegetative region and in the infl., of the two branches arising at any node, one (that in the axil of β) tends to outgrow the other and after two or three branchings the weaker one often does not develope at all, so that a cincinnus arises. The whole infl. is very characteristic, and such an one is often called a caryophyllaceous infl. (p. 64).

The flrs. are ☿ and regular, but often not isomerous. As a type, the formula of Lychnis may serve: K (5), C 5, A 5 + 5, $\underline{G}$ (5), with free central placenta, unilocular. Ovules usually ∞, in double



Floral diagrams of (1) *Silene inflata* and (2) *Paronychia sp.* (after Eichler), showing the ordinary type of flr. in Silenoideae and the most reduced type of Alsinoideae; $\alpha\beta$ = bracteoles.

rows corresponding to the cpls., rarely few or 1 (Paronychieae), usually campylotropous. In most cases the flr. is obdiplostemonous as may be recognised by the cpls. (when 5) being opposite the petals.

Frequently, reduction of the number of parts occurs, *e.g.* we may have G (3) or (2) or rarely (4); A 4 + 4, or 5, 3, 2, or 1, and in other cases the corolla may abort (Sagina sp., Herniaria, &c.). The ovary, sta., and corolla are sometimes borne on an androphore (*e.g.* Lychnis), an elongation of the axis between calyx and corolla. The petals are sometimes provided with a ligule (*e.g.* Lychnis), and are often bifid. At the base of the ovary are often seen traces of the septa, which in the upper part do not develope; in some cases the placenta is basal.

Biologically, as well as morphologically, the order separates into two distinct groups, a higher type, the *Silenoideae*, and a lower, the *Alsinoideae*. All secrete honey at the base of the sta., but while in the A. the flr. is wide open, so that short-tongued insects can reach the honey, in the S. a tube is formed by the gamosepalous calyx; in this stand the claws of the petals and the sta., partly filling it up, and rendering the honey inaccessible to any but long-tongued insects, especially bees and Lepidoptera. The latter class, especially in the Alps (see Müller's *Alpenblumen*), are the chief visitors, and many of the S. are adapted to them—by length of tube, red and white colours, night-flowering in many sp., or emission of scent only at night, &c. The flrs. are commonly protandrous. Many A. are gynodiœcious (cf. Labiatae).

The fruit is usually a capsule, containing several or very many seeds. It opens in nearly all cases by splitting from the apex into a certain number of teeth which bend outwards, leaving an opening at the top. The splitting may take place in as many, or in twice as many lines as there are cpls. The seeds cannot escape from the capsule unless it be shaken, *e.g.* by wind or animals, and as they are small and light they thus have a good chance of distribution. The embryo is usually curved round the perisperm (in a few cases it is nearly straight).

Classification and chief genera (after Pax):

I. *SILENOIDEAE* (flr. gamosepalous, hypogynous):
- 1. *Lychnideae* (calyx with commissural ribs): Silene, Lychnis.
- 2. *Diantheae* (no commissural ribs): Gypsophila, Dianthus.

II. *ALSINOIDEAE* (flr. polysepalous; sta. often perigynous).
- *a.* Fruit a capsule opening by teeth.
  - 1. *Alsineae* (styles free to base; leaf exstip.): Stellaria, Cerastium, Sagina, Arenaria.
  - 2. *Sperguleae* (do., but leaf stip.): Spergula, Spergularia.
  - 3. *Polycarpeae* (styles joined at base): Drymaria, Polycarpon.
- *b.* Fruit an achene or nut.
  - 4. *Paronychieae* (flrs. all alike; stipules): Corrigiola, Paronychia, Illecebrum, Herniaria.
  - 5. *Dysphanieae* (do. but leaves exstip. alt.): Dysphania.
  - 6. *Sclerantheae* (do.; leaves exstip. opp.): Scleranthus.

7. *Pterantheae* (flrs. in 3's, the 2 laterals more or less aborted): Pteranthus.

Benth.-Hooker separate off the last 4 of these groups as an independent order under the name *Illecebraceae*, which they place in Monochlamydeae Curvembryae, whilst retaining the rest of the order (*Caryophylleae*) in Polypetalae Caryophyllinae. This is an unnatural separation of closely allied groups. Eichler and Warming retain the order in the wider sense, placing it in Curvembryae. See discussion of relationships of these orders in *Nat. Pfl.* (Caryophyllaceae, p. 68). The relationships are thus given by Pax:

$$\begin{array}{ccccc} & & \text{Caryophyllaceae} & & \\ \text{Amarantaceae} & & \uparrow & & \text{Aizoaceae} \\ & \Big\} \leftarrow & \text{Phytolaccaceae} & \rightarrow \Big\{ & \\ \text{Chenopodiaceae} & & \downarrow & & \text{Nyctaginaceae} \\ & & \text{Portulacaceae} & & \end{array}$$

Caryophylleae (Benth.-Hooker). See above.

Caryophyllinae (Benth.-Hooker). The 4th cohort of Polypetalae (p. 132).

Caryophyllus Linn. = Eugenia Linn. *C. aromaticus* L. = E. caryophyllata.

Caryopteris Bunge. Verbenaceae (V). 5 sp. Himal. to Japan.

Caryota Linn. Palmae (IV. 6). 10 sp. E. Ind. Stem columnar; leaves bipinnate. The infl. is composed of a number of equal branches hanging down like a brush. They appear on the stem in descending order, the oldest in the crown, the younger lower down in the axils of the old leaf-sheaths. Flrs. in groups of 3, one ♀ between two ♂. Sta. 9—∞. Cpl. 1. Fruit a berry. *C. urens* L. is largely cultivated; it yields palm sugar (see Arenga), sago (see Metroxylon), fibre, wood, &c.

Cascarilla Wedd. Rubiaceae (I. 4). 20 sp. S. Am. United to Ladenbergia in *Nat. Pfl.* The bark of some sp. resembles that of Cinchona (see also Croton), but the amount of alkaloid is very small.

Casearia Jacq. Flacourtiaceae (Samydaceae Benth.-Hooker). 120 sp. trop.

Casimiroa La Llave. Rutaceae (IX). 2 sp. Cent. Am.

Cassebeera Kaulf. Polypodiaceae. 3 sp. Brazil.

Cassia Linn. Leguminosae (II. 5). About 400 sp. trop. and warm temp. (except Eur.). Trees, shrubs and herbs with paripinnate leaves and stipules of various types. Flr. zygomorphic, but with petals almost equal in size. The sta. may be 10, but the 3 upper ones are usually reduced to staminodes or absent. The anthers usually open by pores. The 5 upper sta. are generally short, whilst the 2 lower are long and project outwards. In many sp. two forms of flr. occur, one in which the lower sta. project to the left, the other in which they project to the right. It was once thought that this was a kind of heterostylism, but both types of flr. occur on one plant, and self-fertilisation is common.

It would appear to be simply another case of variation in symmetry, like Exacum or Saintpaulia. In many sp. a division of labour takes place among the sta. (cf. Heeria); the insect visitors eat the pollen of the short sta. and carry away on their bodies that of the long sta. There is no honey in the flr. The fruit is often chambered up by 'false' septa running across it—outgrowths from the placenta.

Many sp. of C. are cultivated for their leaves, which when dried form the drug senna. Alexandrian senna is the product of *C. acutifolia* Delile, Italian of C. *obovata* Collad., Arabian of *C. angustifolia* Vahl. *C. Fistula* L., the purging Cassia or pudding-pipe tree, has its seeds embedded in pulp, which is used as a laxative.

Cassine Linn. Celastraceae. 20 sp. S. Afr., Austr., Polynes., trop. Am. See Elaeodendron.

Cassinia R. Br. Compositae (IV). 18 sp. S. Afr., Austr. N. Z.

Cassiope D. Don. Ericaceae (II. 4). 7 sp. boreal. The leaf is very much rolled back (see order and cf. Empetrum); in *C. Redowskii* G. Don it is actually hollow.

Cassytha Linn. Lauraceae (II). 15 sp. trop., esp. Austr. Parasites with the habit of Cuscuta.

Castalia Salisb. = Nymphaea Linn. (*C. speciosa* Salisb. = N. alba.)

Castanea Tourn. ex Linn. (excl. *Castanopsis* Spach). Fagaceae. 3 or 4 sp. N. Hemisph. *C. vulgaris* Lam. (*sativa* Mill.) is the Chestnut. The ♂ flrs. are in dichasia of 3—7 flrs., the ♀ in groups of 3, yielding 3 nuts, enclosed in the prickly cupule (cf. others of order and Aesculus). The fruit is edible and the tree also yields useful wood and bark (used in tanning). See order for floral diagram.

Castanopsis Spach. Fagaceae. 25 sp. trop. India. United to Castanea in *Nat. Pfl.*

Castanospermum A. Cunn. Leguminosae (III. 1). 1 sp. sub-trop. Austr., *C. australe* A. Cunn., the Australian chestnut, so called because its seeds, when roasted, taste like chestnuts.

Castilleja Mutis. Scrophulariaceae (III. 12). 31 sp. N. Am., As., S. Am. (the painted lady or paint-brush). The upper leaves, or sometimes only their outer ends, are brightly coloured, adding to the conspicuousness of the flrs. (cf. Cornus, Poinsettia, &c.).

Castilloa Cervant. Moraceae (II). 2 or 3 sp. Cent. Am., Cuba. The latex of *C. elastica* Cerv. yields caoutchouc (see Hevea, &c.).

Casuarina Linn. Casuarinaceae. About 25 sp. Austr., Polynes., &c. Trees, often of weeping habit, with long slender green branches, cylindrical and deeply grooved. At the nodes are borne whorls of scale-leaves like those of Equisetum. The stomata and green tissue are at the bases of the grooves, whilst the ridges are formed of sclerenchyma, so that the plant is markedly xerophytic. Flrs. unisexual. The ♂ are borne in terminal spikes on short lateral branches. The internodes are short and at every node is a cup (formed of the combined bracts) with several sta. hanging out over the edge. Each represents a ♂ flr.

and has a 2-leaved perianth and 2 bracteoles. The ♀ flrs. are borne in dense spherical heads. Each is naked in the axil of a bract, has 2 bracteoles, and consists of 2 cpls., syncarpous, the posterior loc. empty, the anterior containing 2 or more ovules. The long styles hang out beyond the bracts and wind-fertilisation occurs. Afterwards the whole head becomes woody (bracts as well) enclosing the ripening seeds and protecting them from drought, &c. The seed is winged and is enclosed in the woody bracteoles. For further details see order. The wood of these plants (beef-wood) is valued for its extreme hardness; several sp. are used, known in Austr. as she-oak, forest-oak, &c. The green shoots are used as fodder for cattle.

Casuarinaceae. Dicotyledons (Archichl. Fagales?). Only genus Casuarina (*q.v.*). The place to be assigned to this order in the natural system has been much disputed. Its nearest allies seem to be the Betulaceae. In 1891 Treub discovered the chalazogamic fertilisation (see art. *Chalazogamae*) and proposed to remove it from its place near the B. Later discoveries however show that these plants too are chalazogamic, as also Juglans, and thus C. may still be kept beside them until further study shows whether the classification of the more primitive Dicotyledons must be entirely altered.

Casuarineae (Benth.-Hooker) = preceding. Placed in Unisexuales.

Casuariniflorae (Warming). The 2nd cohort of Choripetalae (p. 137).

Catabrosa Beauv. Gramineae (X). About 7 sp. temp. (1 Brit.).

Catalpa Scop. Bignoniaceae (II). 10 sp. Am., E. As. *C. bignonioides* Walt. is often grown in parks. It yields a very durable timber.

Catananche Linn. Compositae (XIII). 5 sp. Medit.

Catasetum Rich. Orchidaceae (17). 30 sp. trop. Am. Epiphytes. The flrs. show an extraordinary polymorphism, 3 widely different forms occurring on different (or sometimes on the same) stocks. For a long time these were regarded as separate genera, but it is now known that they are all forms of C. The old genus C. is the ♂ form, *Myanthus* Lindl. the ☿ and *Monachanthus* Lindl. the ♀. The labellum is uppermost in the flr. The pollinia are ejected with great violence when one of the horns of the column is touched. For details see Darwin's *Orchids*, p. 178; Rolfe in *Linn. Soc. Journ.*, 27, 1890, &c.

Catesbaea Linn. Rubiaceae (I. 8). 6 sp. W. Ind.

Catha Forsk. Celastraceae. 1 sp., *C. edulis* Forsk., trop. Afr. The leaves are used by Arabs in the same way as tea, under the names Khat or Cafta.

Cathcartia Hook. f. Papaveraceae (II). 2 sp. Himal., China.

Cattleya Lindl. Orchidaceae (13). 20 sp. trop. Am., largely cultivated for their showy flrs. The labellum encloses the column but is not united to it. From its base a nectary runs down into the ovary, The action of the parts of the flr. is like that of Epipactis (Darwin, *Orchids*, p. 143).

Caucalis Linn. (incl. *Torilis* Adans). Umbelliferae (8). 18 sp. N. Hemisph., S. Afr. 5 in Brit. (hedge-parsley, &c.).

Cayaponia Silva Manso. Cucurbitaceae (III). 70 sp. trop. Am., 1 Afr.

Ceanothus Linn. Rhamnaceae. 40 sp. Am., often cultivated as ornamental shrubs.

Cecropia Linn. Moraceae (III). 30—40 sp. trop. Am. Trees of rapid growth, with very light wood, used for floats, &c. The infl. is a very complex cyme (see *Bot. Centr.* 57, p. 6). *C. peltata* L. is the trumpet tree, so called from the use made of its hollow stems by the Uaupès Indians (Wallace, *Amaz.* ch. XII). The hollows are inhabited by fierce ants (*Azteca* sp.) which rush out if the tree be shaken, and attack the intruder. Schimper has made a thorough investigation of this *symbiosis* (or living together for mutual benefit) of plant and animal, showing that there is here a true case of myrmecophily as in *Acacia sphaerocephala* (*q.v.*). These ants protect the C. from the formidable leaf-cutter ants. Several adaptations are to be seen in the tree. The internodes are hollow but do not communicate directly with the air. Near the top of each however is a thin place in the wall. A gravid female ant burrows through this and brings up her brood inside the stem. The base of the leaf-stalk is swollen and bears food bodies (cf. Acacia) on the lower side, upon which the ants feed. New ones form as the old ones are eaten. Several other sp. show similar features. A very interesting point, that goes to show the true adaptive nature of these phenomena, is that in one sp. the stem is covered with wax which prevents the leaf-cutting ants from climbing up, and in this sp. there are neither food-bodies nor the thin places in the walls of the internodes. Cecropia trees that are not inhabited by ants fall an easy prey to the leaf-cutters. Müller once observed a tree stripped by them whilst still inhabited by Azteca; investigation showed that it was because the cold had rendered the latter incapable of fighting.

Cedrela P. Br. Meliaceae. 20 sp. trop. Many yield valuable timber, *e.g.* *C. odorata* L., the West Indian Cedar, used in making cigar-boxes, &c., *C. Toona* Roxb., the Cedar-wood of S. India, *C. australis* F. von Muell, the Australian red Cedar, &c.

Cedronella Riv. Labiatae (VI. 3). 9 sp. N. Am., Japan, Canaries.

Cedrus (Tourn.) Mill. Coniferae (Arauc. 1 b; see C. for genus characters). 3 sp., *C. Libani* Barrel. (Cedar of Lebanon), *C. atlantica* Manetti (Atlantic Cedar; Algeria) and *C. Deodara* Loud. (Deodar; Himalaya); all are probably varieties of one sp. whose distribution has become discontinuous (p. 146). They are handsome evergreen trees (often planted for ornament in Brit.) with needle leaves and both long and short shoots; the latter may continue to grow for several years and may even develope into long shoots. Flrs. solitary, in the position of short shoots. The cone ripens in 2—3 years. The wood is very durable and is highly valued for building, &c.

Ceiba Medic. = Eriodendron DC. (*C. pentandra* Gaertn. = E. anfractuosum; *C. Casearia* Medic. = E. orientale).

Celastraceae. Dicotyledons (Archichl. Sapindales). About 38 gen. with 280 sp., trop. and temp. Trees or shrubs with simple, often leathery, leaves and cymose (rarely racemose) infl. Flr. small, regular, usually ☿. K 4—5, free or united, C 4—5. There is usually a well marked disc, on the upper side or edge of which are borne 4—5 sta. Ovary superior, of 2—5 cpls., usually with as many loculi, sometimes partly sunk in the disc. Ovules generally 2 in each loc., usually erect, anatropous or apotropous. Fruit a loculicidal capsule, samara, drupe, berry or indehiscent capsule. Seed usually with brightly coloured aril. Endosperm usually present. *Chief genera:* Euonymus, Celastrus, Cassine. Placed in Celastrales by Benth.-Hooker, in Frangulinae by Warming.

Celastrales (Benth.-Hooker). The 9th cohort of Polypetalae (p. 133).

Celastrineae (Benth.-Hooker) = Celastraceae.

Celastrus Linn. Celastraceae. Over 40 sp. As., Austr., Polynes., N. Am. Climbing shrubs with fruit like Euonymus.

Celmisia Cass. Compositae (IV). 27 sp. N. Z., &c.

Celosia Linn. Amarantaceae (I). 35 sp. trop. and temp. The most interesting is *C. cristata* L., the Cock's-comb, a cultivated (but now hereditary) monstrosity, in which fasciation (p. 23) of the flrs. of the infl. occurs.

Celsia Linn. Scrophulariaceae (I. 1). 37 sp. Medit., Afr., As.

Celtis Tourn. Ulmaceae. 60 sp. N. temp. and trop. Like Ulmus, but with introrse anthers, a drupe fruit, and a curved embryo. The fruit of the nettle-tree (*C. australis* L.) is eaten in Spain, &c. The wood of this sp. is useful for turning, and the tree is also used as a fodder-plant in India.

Cenchrus Linn. Gramineae (V). 12 sp. trop. and warm temp. The spikelet is surrounded by an involucre of sterile spikelets, which in some sp. become hard and prickly, surrounding the fruit and acting as a means of distribution by animals (cf. Tribulus, &c.). *C. tribuloides* L. is a very troublesome pest in the wool-growing districts of N. Am.

Cenia Comm. ex Juss. Compositae (VII). 9 sp. S. Afr. Included in Cotula Linn. in *Nat. Pfl.*

Centaurea Linn. Compositae (XI). 470 sp. chiefly Medit.; a few in Eur., As., trop. Afr., Am., Austr. Several in Brit. *e.g. C. nigra* L. (knapweed), *C. Scabiosa* L., *C. Cyanus* L. (blue-bottle or cornflower). In the last two the outer flrs. are neuter with enlarged corolla (cf. Hydrangea). *C. Calcitrapa* L. (star-thistle) has long spiny involucral bracts. The flr. of C. shows the usual construction but the sta. are sensitive to contact and when touched (*e.g.* by insects probing for honey) contract, thus forcing out the pollen at the top of tube. In *C. montana* L. and other sp. there is a nectary on each bract of the involucre. Numbers of ants are thus attracted, which may perhaps frighten away other harmful insects (p. 116). The secretion only goes on whilst the flrs. are open and may also be explained as serving to keep the ants away from the flrs., whose honey they would steal without making any return.

Centradenia G. Don. Melastomaceae (I). 4 sp. Mexico, Cent. Am. *C. rosea* Lindl. shows habitual anisophylly (p. 47).

Centranthus DC. Valerianaceae. 12 sp. Medit., Eur. *C. ruber* DC. is the red spur-valerian of gardens. The corolla is spurred at the base, and at the end of the spur honey is secreted. The tube of the corolla has a longitudinal partition dividing it into two narrow tubes, one containing the style, the other, lined with downward-pointing hairs, leading to the spur. The flr. is protandrous, and the long narrow tube prevents any but long-tongued insects obtaining the honey.

Centrolepidaceae. Monocotyledons (Farinosae). 6 gen. with 32 sp. Austr., N. Z., S. Am., Polynes., S. E. As. Small grass-like herbs with spikes of small flrs., which are ☿ or unisexual, naked or with 1—3 hair-structures round them. Sta. 1—2, Cpls. 1—∞, superior, each with one pendulous orthotropous ovule. *Chief genus:* Centrolepis. See *Nat. Pfl.* for details. Placed in Glumaceae by Benth.-Hooker, in Enantioblastae by Warming.

Centrolepis Labill. Centrolepidaceae. 20 sp. Austr., E. As.

Centrolobium Mart. Leguminosae (III. 8). 3 sp. trop. Am. The pod is winged for winged-carriage and is very spiny.

Centropogon Presl. Campanulaceae (III). 90 sp. trop. Am.

Centrosema Benth. (*Bradburya* Rafin. of *Nat. Pfl.*) Leguminosae (III. 10). 30 sp. Am.

Centrospermae. The 10th cohort of Dicotyledons (Archichl.). See p. 128, and refer to art. Caryophyllaceae for relationships.

Centunculus Dill. Primulaceae (III). 3 sp. temp. and sub-trop. (1 in Brit.).

Cephaelis Sw. = Uragoga Linn. The boundaries of these two genera and the nearly related Psychotria Linn. are very ill-defined. The grouping used in this work is that of Schumann in *Nat. Pfl.*

Cephalanthera Rich. Orchidaceae (4). 10 sp. N. temp. 3 in Brit. There is no rostellum and the pollen germinates *in situ*, fertilising its own stigma (Darwin, *Orchids*, p. 80). The lateral staminodes (see order) are easily seen upon the column. Darwin regards C. as a degraded Epipactis.

Cephalaria Schrad. Dipsacaceae. 30 sp. Medit.

Cephalocereus Pfeiff. = Cereus Haw.

Cephalotaceae. Dicotyledons (Archichl. Rosales). Only genus Cephalotus (*q.v.*). Placed in Saxifraginae by Warming. Benth.-Hooker include C. in Saxifragaceae, from which it differs in having a fully free and apocarpous ovary and basal ovules.

Cephalotaxus Sieb. et Zucc. Coniferae (Taxaceae, 4; see C. for genus characters). 4 sp. Japan, China. *C. Fortunei* Hook. is commonly grown in shrubberies. All the shoots are of unlimited growth. Flrs. diœcious, the ♂ in heads in the axils of the leaves of the preceding year, the ♀ stalked, of several pairs of leaves each with a short axillary shoot bearing two ovules. Seeds 1—2, with fleshy aril.

Cephalotus Labill. Cephalotaceae. 1 sp., *C. follicularis* Labill., in marshes at King George's Sound, W. Austr. A most interesting plant, having pitchers like those of Nepenthes or Sarracenia, though it is not nearly related to either. The lower leaves of the rosette form pitchers, the upper are flat and green (cf. this division of labour with that found in N. and S.). The pitcher has much the same structure as that of N. and catches insects in the same way. [See p. 178.] Flr. ☿, apetalous. Perianth 6, valvate. Sta. 6+6. Cpls. 6, free, standing round the apex of the axis, each with 1 (rarely 2) basal erect anatropous ovule with dorsal raphe. Follicle with 1 seed; embryo small in fleshy endosperm.

Cerastium Linn. (incl. *Moenchia* Ehrh.). Caryophyllaceae (II. 1). 50 to 100 sp. N. temp. 5 or more in Brit. (mouse-ear chickweed).

Cerasus (Tourn.) Linn. = Prunus Linn. *C. Avium* Moench., *Laurocerasus* Loisel., *lusitanicus* Loisel., *Padus* Delarb. = P. Avium, &c.; *C. vulgaris* Mill. = P. Cerasus.

Ceratolobus Blume. Palmae (III. 5). 2 sp. Sunda Is. (p. 148).

Ceratonia Linn. Leguminosae (II. 5). 1 sp. Medit., *C. Siliqua* L. the carob-tree. The pods (Algaroba or St John's bread) are full of a juicy pulp containing sugar and gum, and are largely used for feeding domestic animals. The seeds are said to have been the original of the carat weights of jewellers.

Ceratophyllaceae. Dicotyledons (Archichl. Ranales). Only genus Ceratophyllum (*q.v.*). As is usually the case with highly adapted water-plants (see p. 158) it is very difficult to decide upon a position for the C. in the scheme of classification. The one free cpl. and several perianth leaves seem to place them in Ranales, and they are distinguished from Nymphaeaceae by the orthotropous ovule, whorled leaves, &c. Eichler placed them in Urticinae, Benth.-Hooker as an anomalous order of Monochlamydeae. Warming places them in Polycarpicae (= Ranales).

Ceratophylleae (Benth.-Hooker) = preceding.

Ceratophyllum Linn. Ceratophyllaceae. 3 sp. cosmop., of which *C. demersum* L. and *C. submersum* L. occur in Brit. (hornworts). Water-plants, rootless, with thin stems and whorls of much-divided submerged leaves. The plant decays away behind as it grows in front, so that vegetative multiplication occurs by the setting free of the branches. The old leaves are translucent and horny, whence the common name. Winter buds are not formed, the plant merely sinking to the bottom in autumn and rising again in spring.

Flrs. monoecious, axillary, sessile, with sepaloid perianth. In the ♂, P about (12), hypogynous; A 12—16 on convex recept., with oval non-cutinised pollen. In the ♀, P (9—10), hypogynous; G 1, the midrib anterior; ovule 1, orthotropous, pendulous. Achene crowned by the persistent style, which in *C. demersum* is hooked. Seed albuminous. The flr. is water-pollinated; the anthers break off and float up through the water (each has a sort of float at top of theca); the pollen is of the same specific gravity as water (cf. Zostera) and thus drifts about till it comes in contact with a stigma.

Ceratopteris Brong. Polypodiaceae. Only sp. *C. thalictroides* Brong., an aquatic fern (floating or rooted in shallow water) found throughout the Tropics. The succulent fronds are eaten as a vegetable in the Indian Archipelago.

Ceratostema Juss. Ericaceae (III. 8). 20 sp. S. Am. Included in Thibaudia H. B. et K. in *Nat. Pfl.*

Ceratostigma Bunge. Plumbaginaceae. 4. sp. Abyss., Himal., China. The total infl. is racemose, the partials dichasial.

Ceratozamia Brongn. Cycadaceae. 6 sp. Mexico.

Cerbera Linn. (incl. *Tanghinia* Thou.). Apocynaceae (I. 3). 6 sp. Ind. to New Caled., Madag.

Cercis Linn. Leguminosae (II. 4). 5 sp. S. Eur., As., N. Am. *C. Siliquastrum* L., the Judas-tree, flowers in the open in Brit. (Judas is said to have hanged himself on one.) The flrs. appear before the leaves, in little bunches on the older twigs, and have a very papilionaceous look, the two lower petals enclosing the essential organs. Serial buds are formed in the leaf axils.

Cereus Mill. (incl. *Cephalocereus* Pfeiff., *Echinocereus* Engelm., *Echinopsis* Zucc., *Pilocereus* Lem.). Cactaceae (I). 220 sp. Am., W. Ind. Most are erect cylindrical forms, rarely branched, with ribs or less often mammillae (see order). A few of the more interesting sp. may be mentioned. *C. giganteus* Engelm. (Texas) is the largest of the cacti; it grows to 70 ft. high and 2 ft. thick with candelabra-like branching (figs. in *Treas. of Bot.* and other books). *C. grandiflorus* Mill. is the night-flowering cactus, whose magnificent and sweetly-scented flrs. open in the evening and wither before morning. Other sp., *e.g. C. triangularis* Mill., behave in the same way. These sp. are mostly trailing forms with adventitious roots upon the stems. *C.* (*P.*) *senilis* Salm-Dyck. is the old-man cactus, so called because of the long white hairs with which it is covered. A number of cases of close resemblance may be found between sp. of C. and sp. of Euphorbia. The fruit of most sp. is edible, and is often made into preserves.

Cerinthe Linn. Boraginaceae (IV. 4). 7 sp. Eur., Medit.

Ceropegia Linn. Asclepiadaceae (II. 4). 80 sp. Afr., As., Austr. Erect or twining herbs or undershrubs, more or less xerophytic. Many have tuberous rootstocks, others are leafless and sometimes have fleshy Stapelia-like stems. The flrs. form a trap like those of *Aristolochia Clematitis*. The corolla tube widens at the base and at the top the teeth spread out, but in some sp. they hold together at the tips, making a sort of umbrella. The tube is lined with downward pointing hairs, and small flies, attracted by the colour and smell, creep into the flr. and cannot escape till the hairs wither, when they emerge with pollinia on their proboscides.

Ceroxylon Humb. et Bonpl. Palmae (IV. 6). 5 sp. N. Andes. *C. andicolum* H. and B. and other sp. yield a wax (secreted on the stems), used for making candles, &c. One tree yields about 25 lbs.

Cestichis Thou. = Liparis Rich.

Cestrum Linn. (*Habrothamnus* Endl.) Solanaceae (IV. 7). 140 sp. trop. and sub-trop. Am. Some are greenhouse plants.

Ceterach Willd. = Asplenium Linn. *C. officinarum* Willd. (ceterach, Brit.) = *A. Ceterach* Linn.

Chaenostoma Benth. Scrophulariaceae (II. 7). 62 sp. S. Afr., 1 in Canary Is., 1 in Somaliland.

Chaerophyllum Linn. Umbelliferae (5). 36 sp. N. temp. *C. temulum* L. is a common weed in Brit.

Chaetanthera Ruiz et Pav. Compositae (XII). 30 sp. Chili, Peru.

Chailletia DC. (*Dichapetalum* Thou.) Chailletiaceae. 45 sp. trop. Several sp. have epiphyllous infl. (cf. Erythrochiton); this has probably arisen by a development similar to what is seen in the infl. of Solanaceae, or in the cushions of Cactaceae.

Chailletiaceae (*Dichapetalaceae*). Dicotyledons (Archichl. Geraniales). 3 gen. with 60 sp. trop. Woody plants with entire, stip. leaves. Flrs. in cymose umbels, &c., sometimes epiphyllous, usually regular, ☿ or unisexual, typically 5-merous. Sepals and petals free or united, the latter often bifid. Axis continued into a cup-like disc or scales. Sta. 5, sometimes epipetalous. Cpls. (2—3) each with 2 ovules. Drupe with 1- or 2-locular stone. No endosperm; seed sometimes with caruncle. *Chief genus:* Chailletia. Placed in Geraniales by Benth.-Hooker, in Frangulinae by Eichler.

Chalazogamae. A division of Angiospermae, proposed by Treub as the outcome of his work upon Casuarina (*Ann. Buitenzorg*, X. 1891, reviewed in *Nat. Science*, Apr. 1892, and in *Beih. z. bot. Centralblatt*, 1892, p. 28). The ovules are developed in a somewhat peculiar way, and in each a number of embryo-sacs (macrospores) form, many of which elongate downwards right into the base (chalaza) of the ovule. Usually only one of these is fertile. At its upper end is a single cell which divides vertically into two and one of these may again divide; the latter is regarded as the equivalent of the canal cell in the archegonium of Pteridophyta, the former is the ovum, which is peculiar among Phanerogams in having a cell-wall. There are also several free nuclei in the embryo-sac, but there are no antipodal cells. The pollen tube passes through the style and the ovarial tissues, *never emerging from them*, to the stalk of the ovule, which it thus enters *from the chalazal end.* It passes upwards inside a sterile macrospore and finally enters the fertile one and fertilises the ovum. The endosperm is formed by the free nuclei in the embryo-sac, in the usual manner.

Both in the development of the macrospores and in the process of fertilisation, the difference between Casuarina and all other known Angiosperms (except to some degree the Loranthaceae) was so marked, and seemed to place Casuarina so much nearer to the Gymnospermae (*q.v.*), that Treub proposed to rearrange the Angiosperms thus :

$$\text{Angiospermae}\begin{cases}\text{Porogamae} & \begin{cases}\text{Dicotyledones.}\\ \text{Monocotyledones.}\end{cases}\\ \cdot & \\ \text{Chalazogamae} & \end{cases}$$

This proposition has not met with general acceptance. The phenomenon has since been observed in various plants of the allied orders Betulaceae, &c. In *Carpinus Betulus* there are several embryo-sacs with tubes (*caeca*) running down into the chalaza, and the pollen tube enters the base of one of these and passes up to the ovum, which is of the ordinary type with synergidae, &c. In *Corylus Avellana* there are several embryo-sacs, but only one sends down a caecum. In *Alnus glutinosa* there is one embryo-sac deep in the nucellus, with no caecum, and *Betula alba* is somewhat similar. Some of the Fagaceae also show signs of this peculiar embryo-sac development but are fertilised by way of the micropyle. In Corylus and in *Juglans regia* the embryo-sac at the time of fertilisation contains the 3 antipodal cells and 5 free nuclei, with one of which the male nucleus coalesces, so that a relationship to Gnetum (see art. Gymnospermae) is perhaps indicated. Ulmus shows signs of chalazogamic fertilisation, though the pollen tube finally reaches the apex of the nucellus, and Plantago also is said to exhibit somewhat similar phenomena, while in Alchemilla sp. the tube enters by the funicle and afterwards runs up through the integument and enters the embryo-sac at the level of the ovum.

We may perhaps accept the view that chalazogamic fertilisation is one of the phenomena attending the passage from gymnospermy to angiospermy, but to base any classification upon it would be premature. [See Nawaschin, *Bull. Ac. St. Petersb.* 1899, *Bot. Zeit.* 1900, p. 38; Murbeck, *Lunds Univ. Arskr.* 36, *Bot. Centr.* 86, p. 121.]

Chamaecyparis Spach. Coniferae (Arauc. 2 c; see C. for genus characters). 4 sp. N. Am., Japan. *C. nutkaensis* Spach. (*Thuya excelsa* Bong.) is the Sitka cypress or yellow cedar; *C. sphaeroidea* Spach (*Thuya sphaeroidalis* Rich.) is the white cedar of N. Am.; *C.* (*Th.*) *pisifera* Sieb. et Zucc. and *C.* (*Th.*) *obtusa* Sieb. et Zucc. are Japanese. All yield useful timber, especially the first two. The genus is much confused with Thuya and Cupressus (in nomenclature).

Chamaedorea Willd. Palmae (IV. 6). 60 sp. trop. and sub-trop. Am. Small reedy palms, often forming suckers. Dioecious.

Chamaelaucium Desf. Myrtaceae (3). 11 sp. W. Austr.

Chamaeorchis Koch. = Herminium Willd. [1 sp. Mts. of Eur., *C.* (*H.*) *alpina* Rich. See Muller's *Alpenblumen*, p. 73.]

Chamaerops Linn. Palmae (I. 2). 2 sp. Medit. *C. humilis* L. is the only sp. of palm found in Eur.

Chavica Miq.—Piper Linn.

Cheilanthes Sw. Polypodiaceae. 55 sp. trop. and temp., esp. on Mts. They are mostly xerophytic and often have the pinnae incurved and the stomata protected by hairs (cf. Empetrum).

Cheiranthus Linn. Cruciferae (IV. 16). 10 sp. Medit. and N. temp. *C. Cheiri* L., the wall-flower, in Brit.

Cheirostemon Humb. et Bonpl. (*Chiranthodendron* Larreat.) 1 sp. Mexico, *C. platanoides* H. et B., the Macpalxochitlquahuitl. Flrs. large; petals 0; sta. 5, united below and spreading out like fingers above.

Chelidonium Linn. Papaveraceae (II). 1 sp. Brit. to E. As., *C. majus* L., the greater celandine.

Chelone Linn. Scrophulariaceae (II. 6). 4 sp. N. Am.

Chenopodiaceae. Dicotyledons (Archichl. Centrospermae). About 75 gen. with 500 sp. with a peculiar and interesting geographical distribution, determined by the fact that they are nearly all salt-loving (halophilous) plants (p. 169). The 10 chief districts characterised by their presence are (according to Bunge), (1) Austr., (2) the Pampas, (3) the Prairies, (4) and (5) the Medit. coasts, (6) the Karroo (S. Afr.), (7) the Red Sea shores, (8) the S.W. Caspian coast, (9) Centr. As. (Caspian to Himalayas—deserts), (10) the salt steppes of E. As. [For full discussion see Volkens in *Nat. Pfl.*] As Schimper and others have shown, the presence of large quantities of salt in the soil necessitates the reduction of the transpiration, so that the plants which grow in such situations will exhibit the characters of xerophytes, and such is the case with this order. They are mostly herbaceous plants (a few shrubs or small trees), with roots which penetrate deeply into the soil, and with leaves of various types, usually not large, often fleshy, and often covered with hairs. These hairs frequently give a curious and very characteristic mealy feeling to the plant. In some halophytes of this order, the leaves are altogether suppressed, and the plant has curious jointed succulent stems like a miniature cactus (*e.g.* Salicornia). Each "limb" embraces the next succeeding one by a sort of cup at its apex. Even more than in their external form, the C. show xerophytic structure in their internal anatomy, for an account of which, as well as the peculiar mode of growth in thickness, see Volkens in *Nat. Pfl.*

The infl. is often primarily upon the racemose type, but the partial infls. are always cymose, at first often dichasial, but with a tendency to the cincinnus form, by preference of the β-bracteole. The flrs. are regular, small and inconspicuous, ☿ or unisexual; their mode of fertilisation is not quite clearly understood. Perianth simple, rarely absent, persistent after flowering, of 5, 3, 2 (rarely 1 or 4) leaves, more or less united, imbricate, sepaloid. Sta. as many as or fewer than the perianth segments, opp. to them, hypogynous or on a disc; anthers bent inwards in bud. Ovary superior (semi-inferior in Beta), 1-loc. with 2 (rarely more) stigmas. Ovule 1, basal, campylotropous. Fruit usually a small round nut or achene. Embryo usually surrounding the endosperm, either simply bent or spirally twisted. Few of the order are useful plants; see Beta, Spinacia, Chenopodium, &c.

Classification and chief genera (after Volkens). The grouping depends on numerous characters and would occupy too much space; the names of the tribes only are therefore given.

A. *CYCLOLOBEAE.* Embryo ring-shaped, horseshoe-like, conduplicate or semi-circular, wholly or partially enclosing the endosperm.

1. *Polycnemeae:* Polycnemum.
2. *Beteae:* Beta.
3. *Chenopodieae:* Chenopodium.
4. *Atriplicieae:* Spinacia, Atriplex.
5. *Camphorosmeae:* Camphorosma, Kochia.
6. *Corispermeae:* Corispermum.
7. *Salicornieae:* Salicornia.

B. *SPIROLOBEAE.* Embryo spirally twisted: endosperm wanting or divided into two masses by the embryo.

8. *Sarcobatideae:* Sarcobatus.
9. *Suaedeae:* Suaeda.
10. *Salsoleae:* Salsola, Haloxylon, Halimocnemis.

Benth.-Hooker and Warming include Basellaceae in C., and place the order in Curvembryae.

Chenopodium (Tourn.) Linn. Chenopodiaceae (3). 60 sp. temp. 9 in Brit. (goosefoot, lamb's-quarters, Good King Henry, &c.). The fruit in many sp. is dimorphic; some have horizontal seeds, some vertical (esp. on the terminal twigs of the cymes). *C. anthelminticum* (*ambrosioides*) L. is the worm-seed or Mexican tea, whose essential oil is used as a vermifuge in the U.S. *C. Quinoa* Willd. is an important food plant in S. Am.; its seeds are boiled like rice. It is also recommended as a substitute for spinach.

Cherleria Hall. = Arenaria Linn.

Chimaphila Pursh. Pyrolaceae. 4 sp. N. temp.

Chimonanthus Lindl. Calycanthaceae. 1 sp. China, *C. fragrans* Lindl., often placed in Calycanthus. The flrs. come out early in the year, before the leaves, are very fragrant, and show marked protogyny with movement of the sta.

Chiococca P. Br. Rubiaceae (II. 13). 7 sp. trop. Am.

Chiogenes Salisb. Ericaceae (II. 5). 1 sp. E. N. Am., 1 Japan (cf. Epigaea).

Chionachne R. Br. Gramineae (I). 2 sp. Indo-mal. and 1 Austr. (*C. cyathopoda* F. von Muell., a valuable fodder-grass).

Chionanthus Royen. Oleaceae (I. 3). 2 sp. N. Am., China. *C. virginicus* Linn. (snowdrop tree) is often grown in shrubberies for its flrs.

Chione DC. Rubiaceae (II. 13). 4 sp. W. Ind.

Chionodoxa Boiss. Liliaceae (V). 4 sp. Crete and As. Minor. *C. Luciliae* Boiss. (glory of the snow) is a favourite border plant.

Chirita Buch.-Ham. Gesneraceae (I). 45 sp. Ceylon, Himal, Indo-mal. United with Didymocarpus in *Nat. Pfl.*, under Roettlera.

Chironia Linn. Gentianaceae (I. 2). 15 sp. Afr.

Chlaenaceae. Dicotyledons (Archichl. Parietales). 7 gen. with about 20 sp. Madag. (p. 148), closely allied to Theaceae. See *Nat. Pfl.*

Chlidanthus Herb. App. Amaryllidaceae (I). 4 sp. S. Am. Sta. with lateral appendages (see order).

Chlora Ren. (*Blackstonia* Huds.). Gentianaceae (I. 2). 3 sp. Medit., Eur. *C. perfoliata* Linn. (yellow-wort) on chalky soil in Brit.

Chloranthaceae. Dicotyledons (Archichl. Piperales). 3 gen. with 35 sp., trop. and sub-trop. Herbs, shrubs, or trees, with opp. stip. leaves. Flrs. small, in spikes or cymes, ☿ or unisexual, sometimes with sepaloid perianth. Sta. 1—3, united to one another and to the ovary. Cpl. 1; ovules few, pendulous, orthotropous. Endosperm oily; no perisperm; embryo minute. *Chief genera:* Chloranthus, Hedyosmum. Placed in Micrembryae by Benth.-Hooker, in Polygoniflorae by Warming.

Chloranthus Sw. Chloranthaceae. 10 sp. E. As., E. Ind. Perianth of one leaf, anterior; the centre sta. has a complete anther, the laterals each half an anther (cf. Fumaria).

Chloris Sw. Gramineae (XI). 40 sp. trop. and warm temp. Several are useful pasture-grasses in Austr., &c.

Chlorogalum Kunth. Liliaceae (III). 3 sp. Calif. *C. pomeridianum* Kunth has a large bulb whose inner parts are used as a substitute for soap (cf. Saponaria). The outer layers yield a quantity of fibre, used for mattresses, &c.

Chlorophora Gaudich. Moraceae (I). 1 sp. W. Afr. and 1 (*C. tinctoria* Gaudich.) trop. Am. The wood of this sp. forms the yellow dye-stuff known as fustic.

Chlorophytum Ker-Gawl. Liliaceae (III). 50 sp. trop. In *C. comosum* Baker the infl. is often replaced by a vegetative mode of propagation, long shoots developing in the axils of the bracts; these weigh the stem down to the soil and take root there.

Chloroxylon Rumph. Rutaceae (VII). 1 sp. E. Ind., *C. Swietenia* DC., the satin-wood. The timber is largely used in veneering, &c., as it takes a high polish. The tree also yields a gum. [Meliaceae B. & H.]

Choisya H. B. et K. Rutaceae (I). 1 sp. Mexico.

Chondrilla (Tourn.) Linn. Compositae (XIII). 18 sp. N. temp.

Choripetalae (Warming) = Archichlamydeae.

Chorispora R. Br. Cruciferae (IV. 19). 12 sp. E. Medit., Cent. As.

Chorizanthe R. Br. Polygonaceae (I. 1). 34 sp. Am. Some possess an ochrea, usually absent in this group. Flrs. usually single inside the involucre (cf. Eriogonum).

Chorizema Labill. Leguminosae (III. 2). 15 sp. Austr.

Chrysalidocarpus H. Wendl. Palmae (IV. 6). 1 sp. Madag. (*C. lutescens* H. Wendl.). Included in Hyophorbe in *Nat. Pfl.*

Chrysanthemum (Tourn.) Linn. (incl. *Pyrethrum* Hall.). Compositae (VII). 100 sp. Eur., As., Afr., Am. *C. segetum* L. (corn-marigold) and *C. Leucanthemum* L. (ox-eye or dog daisy) in Brit. The autumn-flowering C., now so fashionable, are cultivated forms of *C. indicum* L. and *C. sinense* Sabine (China, Japan). As in the Dahlia, all the florets have become ligulate. *C. Parthenium* Bernh. (Eur.) is the feverfew, a popular remedy against slight fevers; *C. cinerarifolium* Vis. yields Dalmatian insect powder (dried and powdered flrs.), and *C. roseum* Adam. Persian powder.

Chrysobalanaceae (Warming) = Rosaceae (suborder VI).

Chrysobalanus Linn. Rosaceae (VI. 13). 3 sp. W. Afr., Am. The style is basal, so that the flr. is slightly zygomorphic. *C. Icaco* L. is the Coco plum, whose fruit is eaten in the W. Ind.

Chrysocoma Linn. Compositae (III). 8 sp. S. Afr. (For *C. Linosyris* L. see Aster.)

Chrysogonum Linn. Compositae (V). 1 sp. E. N. Am.

Chrysophyllum Linn. Sapotaceae (I). 60 sp. trop., esp. Am. Several serial buds are formed in each leaf-axil in some sp., and the undeveloped ones subsequently give rise to flrs. borne on the old wood (p. 156). *C. Cainito* L. is the star-apple, cultivated in the W. Ind. for its edible fruit.

Chrysopsis Ell. Compositae (III). 13 sp. N. Am.

Chrysosplenium Tourn. Saxifragaceae (I). 40 sp. N. temp. 2 in Brit. (golden saxifrage). Small herbs with rhizomes bearing both vegetative and flowering shoots. Infl. cymose. The small greenish flrs. are perigynous and apetalous; they are homogamous and visited by various small insects. Cf. Adoxa.

Chuquiraga Juss. Compositae (XII). 40 sp. S. Am. In each leaf-axil are thorns, probably representing the leaves of an undeveloped axillary shoot; above them is a normal branch.

Chusquea Kunth. Gramineae (XIII). 35 sp. Am. Like Bambusa.

Chysis Lindl. Orchidaceae (15). 6 sp. trop. Am. Epiphytes.

Cibotium Kaulf. = Dicksonia L'Hérit.

Cicendia Adans. Gentianaceae (I. 2). 1 sp., *C. pusilla* Griseb., S. W. Eur. (incl. Channel Is.). [For *C. filiformis* Delarb. see Microcala.]

Cicer (Tourn.) Linn. Leguminosae (III. 9). 14 sp. W. As., Medit. Accessory buds occur in the leaf-axils in some sp. *C. arietinum* L. is the chick-pea or gram, largely cultivated for food in S. Eur. and India.

Cichorium (Tourn.) Linn. Compositae (XIII). 8 sp. Medit., Eur. *C. Intybus* L., the chicory, occurs in Brit. The roots, roasted and ground, are mixed with coffee. *C. Endivia* L. is the endive, used as a pot-herb. The leaves are partly blanched by tying them together.

Cicuta (Tourn.) Linn. Umbelliferae (5). 6 sp. N. Hemisph. *C. virosa* L. (cow-bane or water-hemlock) in Brit. Highly poisonous.

Cimicifuga Linn. Ranunculaceae (2). 9 sp. N. temp. *C. foetida* L. (bugbane, Eur.) is used as a preventive against vermin. The root of *C. racemosa* Nutt. (black nake-root, N. Am.) is used as an emetic in Am. United to Actaea in *Nat. Pfl.*

Cinchona Linn. Rubiaceae (I. 4). 40 sp. Andes. Trees. Flrs. heterostyled in some sp. Important as the source of Peruvian bark, from which are extracted the valuable drugs (alkaloids) quinine, cinchonidine, &c. The tree used to be cut down to obtain the bark and there was danger of its extinction until its cultivation was started on a large scale in Ceylon, Java, and India. Several sp. are used, *e.g.* *C. Calisaya* Wedd. (yellow bark and some of the crown bark), *C. Ledgeriana* Moens (yellow bark, the richest in alkaloid), *C. cordifolia* Mutis (Cartagena bark), *C. officinalis* L. [*condaminea* Humb.] (crown or brown bark), *C. succirubra* Pav. (red bark). [See Markham, *Travels in Peru and India*; Reimers, *Les Quinquinas de culture*, 1900.]

Cineraria Linn. Compositae (VIII). 25 sp. S. Afr. Many sp. of Senecio are often included in this genus.

Cinnamodendron Endl. Canellaceae. 3 sp. Brazil, W. Ind.

Cinnamomum (Tourn.) Linn. Lauraceae (I). 40 sp. S. E. As. Young leaves often red (p. 157). *C. zeylanicum* Nees. (Ceylon) is the cinnamon tree. The spice is the bark of the young shoots, the plant being coppiced under cultivation. *C. Cassia* Blume (China, Japan) yields Cassia bark, often used to adulterate cinnamon. Its flower-buds are used as a spice (*cf.* Eugenia). *C. Camphora* T. Nees & Eberm. (China, Japan, Formosa) is the Camphor tree. The wood is heated with water and the camphor volatilises and is condensed.

Cinnamosma Baill. Canellaceae. 1 sp. Madag.

Cipadessa Blume. Meliaceae. 4 sp. Indo-Mal., Madag.

Circaea Tourn. Onagraceae (VIII). 7 sp. N. temp. and arctic. 2 in Brit. (enchanter's nightshade). Flr. dimerous throughout with one whorl of sta. Fertilisation method like that of Veronica. Fruit hooked.

Circaeaster Maxim. 1 sp. Himal., China. Position doubtful, perhaps near Chloranthaceae or Ranunculaceae (Hooker, *Icones Pl.*, t. 2366). K 2—3, Co, A 1—2, G 1—4; fruits hooked.

Cirrhopetalum Lindl. Orchidaceae (22). 30 sp. Indo-Mal., Masc.

Cirsium (Tourn.) Adans. = Cnicus Tourn.

Cissampelos Linn. Menispermaceae. 70 sp. trop. ♂ infl. cymose. ♀ flr. with peculiar zygomorphic structure; cpl. one, with one sepal and two petals at one side of it. Petals often united.

Cissus Linn. = Vitis Tourn.

Cistaceae. Dicotyledons (Archichl. Parietales). 4 gen. with 160 sp. They grow in dry sunny places, especially on chalky or sandy soil. 3 sp. in S. Am., the rest N. temp. (esp. Medit.). Shrubs and herbs with opp. leaves, often inrolled (cf. Ericaceae), with or without stipules. Glandular hairs are usually present. Flrs. solitary or in cymose infl., ☿, regular. K 5, the two outer ones usually smaller than the inner (they have sometimes been regarded as bracteoles, but these organs are found lower down); C 5 or 3 or 0, convolute (the petals overlap to right or left according as the 3 inner sepals overlap to left or right respectively); A ∞ on a sub-ovarial disc (sta. developed in descending order); $\underline{G}$ (5—10 or 3) 1-loc. with parietal (often projecting) placentae. Ovules ∞ or 2 on each, ascending, orthotropous. Styles free. Capsule loculicidal. Endosperm; curved embryo. *Genera:* Cistus (ovules ∞, capsule 5-valved), Helianthemum (do., 3-valved), Hudsonia (ovules 2, pets. 5), Lechea (ovules 2, pets. 3 or 0). Placed in Parietales by Benth.-Hooker, in Cistiflorae by Warming.

Cistiflorae (Warming). The 10th cohort of Choripetalae (p. 137).

Cistineae (Benth.-Hooker) = Cistaceae.

Cistus (Tourn.) Linn. Cistaceae. 30 sp. Medit. *C. creticus* L. and *C. ladaniferus* L. yield the resin ladanum (not to be confused with laudanum), obtained by whipping the leaves with leather thongs. The drug was largely used in the plague and in nervous diseases, but is now little employed. Many sp. are favourite shrubs (gum-cistus).

Citharexylum Mill. Verbenaceae (II). 20 sp. trop. Am. The common name fiddle-wood is a corruption of Bois-fidèle.

Citriobatus A. Cunn. Pittosporaceae. 2 sp. S. W. Austr.

Citrullus Forsk. Cucurbitaceae (III). 4 sp. Afr., Medit., As. *C. vulgaris* Schrad. is the water-melon. *C. Colocynthis* Schrad. the colocynth, whose fruit furnishes the cathartic drug of the same name.

Citrus Linn. Rutaceae (X). 30 sp. trop. Old World. Shrubs and trees with usually simple leaves, which show a joint at the meeting place of blade and stalk, indicating their derivation from compound leaves like those of most of the order (cf. Berberis). Axillary thorns occur in some sp. (= metamorphosed leaves of the branch shoot). Flrs. in corymbs, ☿. K and C 4—8. Sta. ∞ in irregular bundles, corresponding to an outer whorl only. Cpls. ∞ (6 or more), syncarpous. A second whorl sometimes appears. Frt. a berry with leathery epicarp. The flesh is made up of large cells which grow out from the inner layer of the pericarp.

Many sp. are cultivated in warm countries, for their fruit. *C. Medica* L., the citron, is the parent sp. of several varieties, *e.g.* var. *Limonum* the lemon, var. *acida* the lime, var. *Limetta* the sweet lime. *C. Aurantium* L. is the orange, with its varieties *Bergamia*, the Bergamot orange (from which the perfume is obtained), and *Bigaradia* the Seville or bitter orange. *C. decumana* Murr. is the shaddock.

For details see De Candolle's *Orig. of Cult. Plts.* p. 176, or *Treas. of Bot.*

Cladium P. Br. Cyperaceae (II). 40 sp. trop. and temp., esp. Austr. *C. Mariscus* R. Br. (*germanicum* Schrad.), the only Brit. sp., is still abundant in Wicken Fen near Cambridge (the only bit of true fen now left), where it is cut as a crop. Formerly it abounded in the Fens and "was largely used for lighting fires at Cambridge and other places" (Babington).

Cladrastis Rafin. Leguminosae (III. 1). 1 sp. Japan &c., and 1 sp. E. N. Am. (cf. Epigaea). The wood of the latter (*C. tinctoria* Rafin., the yellow-wood) yields a yellow dye.

Claoxylon A. Juss. Euphorbiaceae (A. II. 2). 40 sp. trop. Old World.

Clarkia Pursh. Onagraceae (IV). 5 sp. W. N. Am. Favourite border plants. Mechanism of flr. as in Epilobium.

Clausena Burm. f. Rutaceae (X). 15 sp. trop. Afr., Ind., Austr.

Clavija Ruiz et Pav. Myrsinaceae (I). 22 sp. trop. Am. Trees of palm-like habit (p. 155), often with flrs. on the old wood (p. 156).

Claytonia Gronov. ex Linn. Portulacaceae. 20 sp. N. temp. and arctic. Two have become naturalised in Brit. There are no stipules. Flrs. in sympodial cymes. Before pollination the flower-stalk is erect; the flr. is protandrous, with outward movement of the sta. after dehiscence. Honey, secreted at the base of each petal, is accessible to short-tongued insects. After pollination, the stalk bends downwards through 180°, to return once more to the erect position when the fruit is ripe. The capsule contains 3 seeds and splits into 3 valves, the seeds lying across the lines of splitting. The inner surfaces of the valves contract as they dry and shoot out the seeds (cf. Buxus, Viola; fig. in *Ann. of Bot.* 1892).

Clematis Dill. ex Linn. (incl. *Atragene* L.). Ranunculaceae (3). 170 sp. cosmop. *C. vitalba* L. (traveller's joy) in Brit. Mostly climbing shrubs with opp., usually compound, leaves. The lower sides of the petioles are sensitive to contact. The petiole bends once round the supporting object, then thickens and becomes lignified (see p. 172). Flrs. in cymes; calyx coloured; no petals or honey secretion. The style often remains persistent upon the fruit and becomes hairy, thus forming a mechanism for wind-distribution.

Cleome Linn. Capparidaceae (I). 90 sp. trop. and warm temp. The disc is usually more developed on the posterior side and may bear scales. The gynophore varies much in length. In *C. heptaphylla* L. (?) there are two round shiny outgrowths at the base of the upper petals; these look like honey drops even when not secreting, and may be compared with the "sham-honey" drops of Lopezia. The floral mechanism of C. requires investigation.

Clerodendron Linn. Verbenaceae (IV). 90 sp. trop. and warm temp. *C. Thompsonae* Balf. is a favourite hot-house plant. It has a red calyx and white corolla. The sta. project so as to form the landing place for insects, and when they are ripe the style is bent down. Afterwards the sta. roll up and the style takes their place. *C. fistulosum* Becc. has hollow internodes inhabited by ants (see Cecropia and Myrmecodia).

Clethra Gronov. Clethraceae. 25 sp. Canaries, N. Am., E. As.

Clethraceae. Dicotyledons (Sympet. Ericales). An order composed of the single genus Clethra, often considered, *e.g.* by Benth.-Hooker, as an anomalous member of Ericaceae. Shrubs and trees with alternate leaves; flrs. in racemes or panicles, *without bracteoles*, ☿, regular. K 5, C 5, *polypetalous*; A 5 + 5, hypogynous; *no disc*. Anthers bent *outwards* in bud: pollen in *single* grains. Ovary 3-loc.; style with 3 *stigmas*. Capsular fruit. Seed with endosperm. The characters given in italics are those in which C. differ from Ericaceae, and taken together fairly justify the separation.

Clianthus Banks et Soland. (*Donia* Don.) Leguminosae (III. 6). 2 sp. Austr., N. Z. Favourite greenhouse plants.

Clidemia D. Don. Melastomaceae (I). 100 sp. trop. Am.

Cliffortia Linn. Rosaceae (III. 9). 40 sp. S. Afr.

Clinopodium Linn. = Calamintha Tourn.

Clintonia Dougl. = Downingia Torr.

Clitoria Linn. Leguminosae (III. 10). 30 sp. trop. and sub-trop. The flrs. are inverted and the essential organs therefore touch the insect's back, if it alight on the standard.

Clivia Lindl. Amaryllidaceae (I). 3 sp. Cape Col.

Clusia Linn. Guttiferae (IV). 80 sp. trop. and sub-trop. Am. They are mostly climbing epiphytes, clasping the host by anastomosing aerial roots, and frequently strangling it altogether (cf. *Ficus Benjamina*, &c.). The fleshy fruit is probably carried from tree to tree by birds.

Clusiaceae (Warming) = Guttiferae.

Cluytia Linn. Euphorbiaceae (A. II. 5). 28 sp. Afr.

Clypeola Linn. Cruciferae (IV. 17). 12 sp. Medit.

Cneoraceae. Dicotyledons (Archichl. Geraniales). Only genus Cneorum. Placed in Simarubaceae by Benth.-Hooker. Nearly allied to Zygophyllaceae, but separated because they have only one whorl of sta. with no ligules, and have no stipules, but possess oil-glands in the leaves.

Cneorum Linn. Cneoraceae. 12 sp. Medit., Canaries.

Cnestis Juss. Connaraceae. 9 sp. trop. Afr., As.

Cnicus Linn. [incl. *Cirsium* (Tourn.) Adans.]. Compositae (XI). 120 sp. N. Hemisph. Several in Brit. (thistles). The genus is much confused with Carduus.

Cobaea Cav. Polemoniaceae. 6 sp. trop. Am. *C. scandens* Cav. is a favourite greenhouse climber of very rapid growth. It climbs by aid of tendrils (leaf-structures) which are much branched, the branches ending in sharp hooks. The tendril nutates with great rapidity and is highly sensitive to contact (as may be seen by rubbing one side and watching it for 5 minutes); the hooks prevent the nutation from dragging away a branch before it has had time to clasp its support (Darwin, *Climbers*, p. 106). The flr. presents interesting features. The closed bud stands erect on an erect stalk, but when it is going to open, the tip of the stalk bends over. The flower is very protandrous with movement of sta. and styles. At first it is greenish with an unpleasant smell, thus presenting the characters of a fly-flower (p. 92), but afterwards it becomes purple with a pleasant honey-like smell (bee-flower). Afterwards the stalk goes through several contortions (cf. Linaria, and see Scholtz in Cohn's *Beiträge*, VI).

Coccinia Wight et Arn. Cucurbitaceae (IV). 14 sp. trop. As., Afr. The fruit of *C. indica* W. and A. is largely eaten as a vegetable in India.

Coccocypselum P. Br. Rubiaceae (I. 7). 8 sp. trop. Am. Heterostyled.

Coccoloba Linn. Polygonaceae (III. 5). 125 sp. trop. and sub-trop. *C. uvifera* L., and others, produce edible fruit. For *C. platyclada* F. Muell. see Muehlenbeckia.

Cocculus DC. Menispermaceae. About 25 sp. trop. and sub-trop. [The grains known as Cocculus are those of Anamirta.]

Cochlearia Tourn. (incl. *Ionopsidium* DC., *q.v.*, and *Kernera* Medic.). Cruciferae (II. 6). 21 sp. Eur., As. Minor. *C. officinalis* Linn. (scurvy-grass) occurs in Brit. in various forms with more or less fleshy leaves, chiefly at the sea-side and on mts. (p. 187); other sp. also occur, including *C. Armoracia* L. (horse-radish) as an escape. The thick root of this sp. is esteemed as a condiment.

Cochliostema Lem. Commelinaceae. 1 sp. Ecuador, *C. odoratissima* Lem., a favourite greenhouse plant. The filaments of the fertile sta. develope both laterally and beyond the anthers into large wings. Anther-loculi spiral. See *Nat. Pfl.*, or Masters in *Linn. Soc. Journ.* XIII.

Cochlospermum Kunth. Bixaceae. 13 sp. trop. Mostly xerophytes; some have stout tuberous underground stems; many drop their leaves in the dry season (p. 168).

Cocos Linn. Palmae (IV. 7). 30 sp. trop. S. Am., W. Ind. *C. nucifera* L. (cocoa-nut palm) in all trop. countries, and largely cultivated. It grows especially well close to the sea and its fruit is capable of floating long distances uninjured, hence it forms a characteristic feature in the islands of the Pacific (p. 190). It is a tall palm with pinnate leaves and dense monœcious infl. The fruit is one-seeded. The outer layer of the pericarp is fibrous, the inner extremely hard (the shell of the cocoa-nut as sold in shops). At the base are three marks, corresponding to the three loculi of the ovary, two of which have become obliterated. Under one of these marks is the embryo.

The thin testa is lined with white endosperm, enclosing a large cavity, partly filled with a milky fluid which may serve as a water-supply in germination. This palm furnishes many of the necessaries of existence to the natives of tropical regions, and its products are largely exported from Ceylon and elsewhere. The stems are used in building; the outer wood (porcupine wood) is hard and is used in making ornaments, &c. The leaves (woven into cadjans) are used for thatching; the apical bud may be eaten as a palm-cabbage. The seed is edible; coconut oil is obtained by crushing the endosperm fresh or dried (copra). By pressure, the oil separates into a solid part (stearine, used for candles) and a liquid (oleine); the remains of the endosperm (coconut cake or poonac) are used for cattle-food. The infl.-axis when tapped (*cf.* Agave) yields a sugary fluid, toddy, used fermented or not; its evaporation yields sugar or jaggery, its distillation arrack.

Codiaeum A. Juss. Euphorbiaceae (A. II. 5). 4 sp. Polynes., Austr. *C. variegatum* Blume ("Croton" of tropical gardens; many vars.) is cultivated for its handsome and often curious leaves.

Codonopsis Wall. Campanulaceae (I. 1). 13 sp. As.

Coelebogyne J. Sm. = Alchornea Sw.

Coelia Lindl. Orchidaceae (13). 5 sp. trop. Am.

Coeloglossum Hartm. = Habenaria Willd. [*C.* (*H.*) *viride* Hartm.]

Coelogyne Lindl. (incl. *Pleione* D. Don). Orchidaceae (7). 60 sp. Indo-Mal., S. China.

Coffea Linn. Rubiaceae (II. 14). 30 sp. palaeotrop. (Fröhner in *Bot. Jahrb.* XXV. 233). *C. arabica* L. (Arabian coffee) is largely cult. in the tropics, esp. in Brazil and Java; the great industry formerly existing in Ceylon has been destroyed by attacks of a fungus (*Hemileia vastatrix*) and insects. *C. liberica* Hiern (Liberian coffee) and other sp. are also used. The fruit, a 2-seeded drupe, is like a cherry; the pulp and endocarp are mechanically removed, leaving the ventrally-grooved seeds or coffee-beans. [Raoul, *Culture du Caféier*, Paris.]

Coix Linn. Gramineae (1). 4 sp. India, China. *C. Lachryma* L., Job's tears, cult. as a cereal in the Himal., a drug in Chi. The curious inverted pear-shaped body at the base of each infl. is the sheath of the bract of the infl., hollowed out and containing the 1-flowered ♀ spikelet; the ♂ spikelets project.

Cola Schott et Endl. Sterculiaceae. 14 sp. Afr. The seeds of *C. vera* K. Sch., *C. acuminata* P. de Beauv., and perhaps others, are the Kola nuts, used by the negroes as a condiment; they contain much caffeine and confer the power of sustaining fatigue (*cf.* Erythroxylon).

Colchicaceae (Warming) = Liliaceae (sub-order I).

Colchicum Linn. Liliaceae (1). 30 sp. Eur., W. As., N. Afr. *C. autumnale* L., autumn crocus or meadow saffron, in Brit. Below the soil is a large corm (fig. and description in most text-books). In autumn the flr. appears, projecting out of the soil. The perianth tube is long and the ovary remains below the ground, where it is protected from cold, &c. The flr. is visited by bees, and is protogynous. In the spring the leaves appear and at the same time the capsule is brought above ground by the lengthening of its stalk. The seeds and corms are used in medicine as a remedy in gout.

Coleonema Bartl. et Wendl. Rutaceae (IV). 4 sp. S. Afr.

Coleus Lour. Labiatae (VII). 60 sp. trop. (exc. Am.). Several hybrid forms, with variegated and coloured leaves, are in cultivation.

Colletia Comm. Rhamnaceae. 13 sp. S. Am. The habit is very peculiar; in each axil are two serial buds, of which the upper gives rise to a triangular thorn, while the lower forms flrs. or a branch of unlimited growth.

Collinsia Nutt. Scrophulariaceae (II. 6). 17 sp. N. Am., often cultivated as border-plants. The flr. exhibits a close resemblance, both in shape and mechanism, to that of many Leguminosae.

Collomia Nutt. Polemoniaceae. 18 sp. N. W. Am. and Chili. The seed coat has an outer covering of cells with mucilaginous walls which swell rapidly when wetted, thus anchoring the seed to a suitable place for germination (cf. Brassica, Linum, &c.).

Colocasia Schott. Araceae (VI). 6 sp. E. Ind. Tuberous herbs or small shrubs. Monœcious. Sta. in synandria. *C. antiquorum* Schott, the Taro or Tania, is largely cultivated in the tropics for its rhizomes, which when boiled lose their poisonous nature and form a valuable food stuff.

Columellia Ruiz et Pav. Columelliaceae. 2 sp. Peru, Ecuador. Shrubs with evergreen opp. exstip. leaves. Flrs. in cymes, ☿, nearly regular. K 5, C (5), A 2. Sta. short and thick with irregular broad connective and 1 twisted pollen sac. No disc. $\overline{G}$ (2), imperfectly 2-loc. Ovules ∞, anatropous. Style short and thick with broad 2—4-lobed stigma. Capsule, enclosed in calyx. Endosperm.

Columelliaceae. Dicotyledons (Sympet. Tubiflorae). Only genus Columellia (*q.v.*). This order represents an old and now isolated type (p. 120) and has been placed in many positions in the natural system. It is placed in Personales by Benth.-Hooker.

Columnea Linn. Gesneraceae (I). 70 sp. trop. Am. Several are climbers and epiphytes. Anisophylly is frequent (p. 47).

Columniferae (Warming). The 12th cohort of Choripetalae (p. 137).

Colutea (Tourn.) Linn. Leguminosae (III. 6). 10 sp. S. Eur. to Himal. *C. arborescens* (L. bladder-senna) is frequently cultivated. Its leaves have similar properties to those of senna (Cassia) and are used to adulterate the latter. The pods are inflated and burst on being squeezed. They may break off and blow about and thus scatter the seeds, or may catch the wind while still on the plant, and jerk out the seeds as they sway.

Comarum Linn. = Potentilla Linn. (*C. palustre* L. = P. Com.).

Combretaceae. Dicotyledons (Archichl. Myrtiflorae). 16 gen. with 240 sp. trop. and sub-trop. Trees and shrubs with alt. or opp. simple leaves and no stipules. Many are climbers, some twining, some with hooks formed of the persistent bases of the petioles. Flrs. usually sessile in racemose infls., ☿, regular. Typical formula: K 5, C 5, A 5 + 5. Ovary inferior, 1-loc.; ovules 2—5, anatropous, pendulous. Style simple. There is a disc on the summit of the ovary, sometimes with various outgrowths. Fruit dry, 1-seeded, often winged at the angles. Seed exalbuminous; cotyledons usually twisted spirally. See *Nat. Pfl.* for details. *Chief genera:* Terminalia, Combretum, Quisqualis. Placed in Myrtales by Benth.-Hooker, in Myrtiflorae by Warming.

Combretum Linn. Combretaceae. 125 sp. trop. and sub-trop., exc. Austr. and Polynes. The fruit of *C. butyrosum* Tal. (trop. Afr.) yields a butter-like substance known in Caffraria as Chiquito, and used by the natives in place of butter.

Commelina Linn. Commelinaceae. About 90 sp. trop. *C. coelestis* Willd. is often cultivated. The rhizome of some sp. is edible. The chief interest centres in the flr., where there is division of labour between the sta. (cf. Heeria). The flr. stands out horizontally and the sta. and style project beyond the corolla. The upper 3 sta. (in many sp.) are almost sterile, but the lobes are juicy. The two lateral lower sta. and the median one are fully fertile, the latter bending up so that the anther is opposite the centre of the flr. Bees visiting the flr. alight on the lower petals; in so doing they touch the stigma, and are dusted by the two lower lateral anthers; they then collect pollen from the median anther, and often climb higher up and pierce the upper anthers for honey. In some sp. self-fertilisation occurs as the style and sta. crumple up in withering. [See Macleod in *Bot. Jaarb.*, Gent, II. 1890.] *C. benghalensis* L. has subterranean cleistogamic flrs. (see *Nat. Pfl.*).

Commelinaceae. Monocotyledons (Farinosae). 25 gen. with 300 sp., mostly trop. and sub-trop. Herbs with jointed stems and alt. sheathing leaves. Infl. usually a cincinnus of the type seen in Boraginaceae. Flr. ☿, usually regular, commonly blue. The typical formula is K 3, C 3, A 3 + 3, $\underline{G}$ (3), but some of the sta. are commonly absent or staminodial. Calyx and corolla differ in colour and texture. Ovary 3-loc., with a few orthotropous ovules in each loc. Capsule loculicidal or indehiscent. Endosperm fleshy; seed often arillate. *Chief genera:* Commelina, Tradescantia. Placed in Coronarieae by Benth.-Hooker, in Enantioblastae by Warming.

Commersonia Forst. Sterculiaceae. 10 sp. trop. As., Austr.

Commidendron Burch. Compositae (III). 3 sp. St Helena (p. 148).

Commiphora Jacq. (*Balsamodendron* Kunth). Burseraceae. 50 sp. trop. As., Afr. *C. Myrrha* Engl., and other sp., yield myrrh. The resin exudes from the tree and collects in lumps. It is used in medicine and as a component of incense, &c. *C. opobalsamum* Engl. is said to yield the resin known as Balm of Gilead. Other sp. yield Bdellium and other resins.

Comparettia Poepp. et Endl. Orchidaceae (28). 4 sp. trop. Am.

Compositae. Dicotyledons (Sympet. Campanulatae). The largest order of flowering plants, comprising about 810 genera, with over 11000 sp. —more than 10 % of the total number of sp. of Phanerogams. They are distributed over the greater part of the earth. Although so large an order, the C. are well marked in their characters and cannot be confounded with any other order, though they have a superficial likeness to Dipsaceae and Calyceraceae. [For a genealogical tree of the sympetalous orders with inferior ovary, and their relationships to Umbelliferae, &c., see Höck in *Bot. Centralbl.* 51, 1892, p. 233, and art. *Sambucus.*]

Living as they do in almost every conceivable situation, the C. present great variety in vegetative habit, often within the boundary of a single genus. Of this, Senecio (*q.v.*) is a noteworthy example. Water and marsh plants and climbers are rare in the order, and so also are epiphytes. This latter is an interesting point, for the distribution mechanism of these plants is admirably suited to an epiphytic existence, and xerophily is not uncommon in the order (see p. 174). Another feature of interest is that the enormous majority of this most successful order are herbaceous plants; trees and shrubs are comparatively rare. It is worthy of note that the latter form an important feature in the Composite flora of oceanic islands, the reason for which is not very obvious (see Wallace's *Island Life*).

The leaves are usually alt., frequently radical, opp. in Heliantheae, whorled in a few cases, *e.g. Zinnia verticillata.* Stipules are rarely present. The root is usually a tap-root, sometimes tuberous as in Dahlia, &c., often thickened like that of a carrot, *e.g.* Taraxacum, Cichorium, &c. For further details of vegetative organs reference must be made to individual genera; *e.g.* Aster, Barnadesia, Bellis, Bidens, Cichorium, Dahlia, Espeletia, Gnaphalium, Helianthus, Helichrysum, Lactuca, Mutisia, Petasites, Senecio, Silphium, Taraxacum, &c.

All the tribes with the exception of XII and XIII contain oil-passages in the root, stem, &c. In XIII (Cichorieae), laticiferous vessels are present, commonly containing a milky white latex (*e.g.* lettuce, dandelion).

The infl. is of racemose type, the flrs. being arranged in heads (*capitula*), or rarely in spikes. These heads are again arranged in many cases into larger infls.—racemes, corymbs, &c., or even into compound heads (Echinops, &c.). In this last case, however, the smaller heads contain only one flr. each. The head is surrounded by an involucre of bracts, usually green, which performs for all the flrs. of the head the functions that in most plants are performed by the calices of the individual flrs., viz. protection of the bud and of the young fruit. The flrs. are arranged upon a common receptacle,—the enlarged end of the axis—which may be of various shapes, but is most frequently flat, slightly convex or even spindle-shaped. The shape and the surface-condition of the receptacle are characters of importance in the classification of the order. It may be smooth or hairy, &c.; there may (Helianthus, &c.) or may not (Calendula, &c.) be, upon it, scaly bracts belonging to the individual flrs. In Cynareae these bracts are divided so as to form numerous bristles.

In the simplest case the flrs. of a single head are all alike and ☿, but there are many deviations from this type. The flrs. may be all actinomorphic (*tubular*) or all zygomorphic (*ligulate*); see below. Very commonly however, as in the daisy or sunflower, there is a distinction into a *disc* of actinomorphic flrs., and a marginal *ray* of zygomorphic flrs. Or, as in Centaurea sp. the outer florets may be actinomorphic but different in size from the central ones. The number of ray-florets varies in different sp., but always according to definite rules (see p. 22).

The *distribution of sexes* among the flrs. of a head is another feature which varies much (for details see Hildebrand, *Geschlechter-vertheilung bei den C.*, or Müller, *Fert. of Flrs.*). The most common case is gynomonœcism, the ray-florets being ♀, the disc ☿. This would appear to be a mere correlation due to exigencies of nutrition, and not an "adaptation" (see p. 25); it can hardly be looked upon as advantageous in the direction of cross-fertilisation, in view of the fact that in many sp. the ray-florets are rarely fertilised at all. It seems probable that the extra material in the large corolla is supplied at the expense of the andrœceum. The very large ray-florets of Centaurea sp. and others are completely sterile (cf. Hydrangea, Viburnum, &c.). Other interesting sex-distributions are found in Tussilago, Petasites, &c. (*q.v.*).

The *flower* is fully epigynous, usually 5-merous. The calyx is absent in Ambrosia and its allies, Siegesbeckia, &c.; in some cases it appears only as a slightly 5-lobed rim upon the top of the inferior ovary (cf. Rubiaceae and Umbelliferae); usually it takes the form of hairs or bristles—the *pappus*—and enlarges after fertilisation into a parachute (Dandelion) or into hooked bristles (Bidens) to aid in distribution (see below). Corolla (5), valvate in bud. It may be actinomorphic (tubular) or zygomorphic. Of the latter form there are two varieties, labiate (lipped) and ligulate (strap-shaped). The latter term, strictly speaking, should be applied to those corollas which are strap-shaped in form

Floral Diagram of Composite flr. with pappus (after Eichler). The small outer lines represent the pappus-bristles.

with 5 teeth at the end representing the petals, but is usually also given to those lipped forms where the lower lip is strap-shaped and ends in 3 teeth. Sta. 5, epipetalous with short filaments, alternating with the petals. Anthers introrse, cohering by their edges (*syngenesious*), forming a tube around the style (cf. Lobelia). Ovary inferior, of (2) cpls., with a simple style that forks at the end into two stigmas, an anterior and a posterior (see diagram). The construction of the style and stigma is of importance in the classification of the order. There is often a brush of hairs on the style below the stigmas. Only the inner (upper) surfaces of the stigmas are as a rule receptive to pollen. Ovary 1-loc. with 1 erect, basal, anatropous ovule, which gives an exalbuminous seed with straight embryo, enclosed in the dry indehiscent pericarp. This fruit is usually termed an achene, but of course is, if one adheres strictly to the usual definitions, a pseudo-nut, as its pericarp is partly of axial nature, and there is more than one cpl. It is often crowned with a pappus (see below).

Natural History of the Flower. Being massed together in heads, the individual flrs. may be, and usually are, comparatively very small. By this means this advantage is gained that a single insect visitor may fertilise many flrs. in a short time without having to fly from one to the other, while at the same time there is no loss of conspicuousness, and of course a considerable saving of corolla-material, &c. The various sex-distributions occurring in the order have been mentioned above. Coming now to the mechanism of the individual flr., we find, throughout the order, the same type, the differences between the different genera being in slight and unimportant details. The mechanism itself is simple, but effective. Honey is secreted by a ring-shaped nectary round the base of the style, and is protected from rain and from short-lipped insects by the tube of the corolla. The depth of the tube varies within fairly wide limits, but is never so small as to permit the shortest-lipped insects to obtain the honey. As an order the C. all belong to Müller's floral class B′ (see p. 91), but there is considerable variety in the depth of tube &c., and therefore also in the composition of the group of visiting insects to each. Thus the long-tubed purple-flowered Centaureas &c. are mainly visited by bees and Lepidoptera, while the short-tubed yellow Leontodons or white Achilleas are visited mainly by flies (see Müller's *Fert. of Flrs.*, or *Ann. of Bot.* June 1895).

At the time when the flr. opens, the style, with its stigmas tightly closed against one another, is comparatively short, reaching up to, or projecting a small distance into, the anther tube. The pollen is shed into this and as the style grows it presses the pollen little by little out at the upper end of the tube where it will come into contact with visiting insects. At last the style itself emerges and the stigmas separate. The flr. is now in its female stage. Finally, in a great many cases, the stigmas curl so far back that they touch the pollen upon their own style, so that every flr. is certain to set seed, even though it be by self-fertilisation. In a few cases, *e.g. Senecio vulgaris*, insect visitors are very rare, and the flr. depends entirely on self-fertilisation. The mechanism is about the simplest and most perfect that exists for attaining the desired ends. A striking contrast is seen in the orchids. Here we have bizarre flowers with most elaborate mechanisms, which yet so rarely effect their purpose that an enormous number of seeds have to be developed in every capsule; in the C. on the other hand, we have a simple mechanism, yet so effective that the number of seeds can be reduced to one. An interesting modification of the mechanism is found in *Cynareae* (see Centaurea) where the stamens are irritable. See also Artemisia (wind-fertilised).

The involucral bracts, or ray-florets, or both, often close up over the central flrs. in cold or wet weather, thus protecting the flrs.

Natural History of the Fruit. The ripening fruit-head is generally protected from injury by the involucral bracts, which bend inwards over it, performing the function of a calyx. The calices of the individual flrs. are thus rendered useless in this respect and are, in most C., used for purposes of distribution of the fruit. In the majority of cases, the calyx, after the fertilisation of the flr., grows into the familiar pappus, as seen in dandelions or thistles. This is usually composed of fine hairs, often branched, but in some cases, *e.g.* Achyrachaena, is leafy and membranous. The hairs are hygroscopic and spread out in dry air; this helps in many cases to lever the fruits off the receptacle. In Bidens and others the pappus is formed of stout barbed bristles, serving to cause the fruit to adhere to animals. In Arctium the involucral bracts become hooked at the tips and cling to animals. In Xanthium the receptacle is provided with hooks. In Siegesbeckia the bracts are sticky. A few genera, *e.g.* Helianthus, Bellis, &c., have no special arrangements at all, and the fruits remain upon the common receptacle till jerked off by wind or otherwise. [For other points and for details see genera, and Taliew in *Bot. Centr.* 63, p. 320.]

General Considerations. The C. are generally regarded as occupying the highest position in the Vegetable Kingdom, and are certainly about the most dominant and aggressive order that it contains. Some of the genera, *e.g.* Hieracium, vary so much as almost to defy classification. The success of the order may be put down perhaps to the concurrence of several useful peculiarities, viz.

(1) the massing of the flrs. in heads, surrounded by involucral bracts: from this there results

(*a*) greater conspicuousness, especially when ray-florets are developed; (*b*) a saving of material in the corollas, &c.; (*c*) the fact that one insect visitor may fertilise many flrs. in a short time without having to fly from one to another:

(2) the very simple and effective floral mechanism, which ensures (*d*) protection of honey and pollen; (*e*) exclusion of the very short-lipped (allotropous) insects, but not too great specialisation for a very narrow circle of visitors; (*f*) prevention of self- and chance of cross-fertilisation till the last possible moment; (*g*) certainty of self-fertilisation if the cross fails;

(3) the use of the calices of individual flrs. for purposes of seed-distribution, and the very perfect character of the mechanism.

Taking together all these considerations, and comparing them with the features of rival orders, *e.g.* Cruciferae, Gramineae, Rubiaceae, Leguminosae, none of which have so perfect an "outfit," it is not surprising that the Compositae have been so successful.

Economic uses. The C. furnish but few useful plants (other than border or greenhouse plants). See Lactuca, Cichorium, Cynara, Helianthus, Carthamus, Chrysanthemum, Tanacetum, &c.

Classification and chief genera (after Hoffmann). As might be expected from what has been said in the last paragraph, and from what we see in other large and dominant orders such as Cruciferae, Umbelliferae, &c., the classification of the C. and the determination of their genera is a matter of no small difficulty. For the purposes of this work it would be useless to enter into details; we shall therefore give only the primary groupings and their chief genera. [There are several exceptions to the characters given below.]

[*Abbreviations:* cap. = capitulum; tub. = tubular; lig. = ligulate; homog. = flrs. in head all similar as to sex; heterog. = flrs. of different sex in one head, *e.g.* ray ♀ and disc ☿.]

A. *TUBULIFLORAE*. Flrs. of disc not ligulate. No latex.

I. *Vernonieae* (cap. homog.; flrs. tub., never yellow; anthers arrow-shaped at base, pointed or rarely tailed, with filaments inserted high above the base; stigmas semi-cylindrical, long, pointed, hairy outside); stigmatic papillae all over inner surface: Vernonia.

II. *Eupatorieae* (cap. homog.; flrs. tub., never pure yellow; anthers blunt at base, with filaments inserted at base; stigmas long, but blunt or flattened at tip, with very short hairs; stigmatic papillae in marginal rows): Ageratum, Eupatorium, Mikania.

III. *Astereae* (cap. heterog. or homog.; all or only central flrs. tub.; anthers as in II; stigmas flattened with marginal rows of papillae, and terminal hairy unreceptive portions): Solidago, Bellis, Aster, Erigeron, Baccharis.

IV. *Inuleae* (as IV; corolla in tub. flrs. with 4—5-toothed limb; anthers tailed at base; styles various): Filago, Antennaria, Gnaphalium, Helichrysum, Inula.

V. *Heliantheae* (style with crown of long hairs above the division; anthers usually rounded at base with basally inserted filaments; corolla of disc flrs. actinomorphic; pappus not hairy; involucral bracts not membranous at margins; receptacle with scaly bracts): Espeletia, Silphium, Xanthium, Zinnia, Siegesbeckia, Helianthus, Dahlia, Bidens.

VI. *Helenieae* (as V, but receptacle without scaly bracts): Helenium, Tagetes.

VII. *Anthemideae* (as VI, but involucral bracts with membranous tip and edges; pappus O or abortive): Achillea, Anthemis, Chrysanthemum, Matricaria, Tanacetum, Artemisia.

VIII. *Senecioneae* (as V and VI, but pappus hairy): Tussilago, Petasites, Senecio.

IX. *Calenduleae* (cap. with ♀ ray flrs., and usually ♂ disc flrs., with undivided style; anthers pointed at base; receptacle not scaly; no pappus): Calendula.

X. *Arctotideae* (style, below or at point of division, thickened or with circle of hairs; cap. with lig. ray flrs.; anthers acute at base or with longer or shorter point and with filaments inserted above the base): Arctotis.

XI. *Cynareae* (style as in X; cap. homog. or with neuter, rarely ♀, not ligulate, ray flrs.; anthers usually tailed; receptacle usually bristly): Echinops, Carlina, Arctium, Carduus, Cnicus, Cynara, Centaurea.

XII. *Mutisieae* (cap. homog. or heterog.; ray flrs. when present usually 2-lipped; disc flrs. actinomorphic with deeply-divided limb, or 2-lipped): Barnadesia, Mutisia, Stifftia, Gerbera.

B. *LIGULIFLORAE.* All flrs. ligulate. Latex.

XIII. *Cichorieae*: Cichorium, Rhagadiolus, Picris, Crepis, Hieracium, Leontodon, Taraxacum, Lactuca, Tragopogon.

[The C. are placed in Asterales by Benth.-Hooker, in Aggregatae by Warming.]

Conchophyllum Blume. = Dischidia R. Br.

Coniferae. The most important class of the Gymnosperms, though, like the other classes, better represented in former ages than now. They form 2 orders with 34 genera and 350 sp. Like their past history, their present geographical distribution is of great interest (see *Nat. Pfl.* or Drude's *Pflanzengeog.*, from which the following account is condensed). Most C. are evergreen trees of erect habit, and grow in dense forests, forming one of the characteristic features of the vegetation in many parts of the globe (esp. temp. and sub-trop. and mountains). Beginning in the north we find *Juniperus nana* beyond the limit of trees. This limit is largely marked by the C., passed here and there only by the birch. Within it, in the N. temp. zone are broad areas covered with C. (Larix, Abies, Pinus, &c.). Going S., their importance decreases and at about 40° N. the C. become practically confined to the mountains. Here we find in Japan and China a region of development characterised by Cephalotaxus, Pseudolarix, Cryptomeria, Cunninghamia, Sciadopitys, Chamaecyparis, Ginkgo, &c., mostly endemic genera. In Pacific N. Am. is another region, with *Pseudotsuga Douglasii*, Sequoia, *Cupressus Lawsoniana*, *Thuja gigantea*, and *Libocedrus decurrens*, together with endemic sp. of Abies, Tsuga, Pinus, &c. The Himalaya forms another great centre, with many peculiar sp., *e.g. Cedrus Deodara*, *Pinus excelsa* and other sp., Picea sp. Tsuga sp. &c. The C. of the N. hemisphere are separated from those of the S. by a broad band of tropical forests, &c., only partially broken by groups of C. on the Mts. of the Indo-mal. region and America. In Australia we find Araucaria, Agathis, Podocarpus, &c. In Tasmania, New Zealand and Chili appear Phyllocladus, Fitzroya, &c. S. America has Araucaria sp. Podocarpus sp., and others. Few genera and no sp. of C. appear in both N. and S. hemispheres; each sp. is limited to a well-defined area.

The C. are trees or shrubs, usually of monopodial growth, often reaching considerable or even (Sequoia) gigantic size. Typically, as may be seen at a glance in a fir or larch plantation, a certain amount of growth is made each year and a number of branches are also formed much at the same level, so that in trees of moderate size the number of 'whorls' of branches is an index of the age. Later on the lower branches usually die off and the branching near the apex becomes less regular. The main stem is radially symmetrical, but the branches, which often grow almost horizontally, have a tendency to dorsiventrality; this is expressed in a two-ranked arrangement of the leaves, twisting of the leaves on their stalks, and so on. Many C. show a difference in their shoots; some (*long shoots*, or *shoots of unlimited growth*) grow continuously onwards, except for the periodical interruption in winter; others (*short shoots*, *shoots of limited growth*, or *spurs*) grow only to a definite size, usually very small, and bear a few leaves. Intermediate conditions occur in Ginkgo, Larix, Cedrus, Taxodium, &c. When both kinds occur the foliage leaves are often borne on the short shoots only (see Pinus &c. for details). The green leaves are usually entire and are either linear or take the form of closely appressed scales (Cupressus, &c.). The only exception is the curious genus Ginkgo, the sole surviving relic of an extinct type which in many respects approximated to the Cycads. Mention may also be made of the curious 'double-needles' of Sciadopitys and the flat green short shoots of Phyllocladus (*q.v.*).

Anatomically, the C. resemble Dicotyledons in all important points. A very general feature of the class (exc. Taxus) is the presence of resin passages in all parts of the plant. The leaves exhibit a somewhat peculiar internal structure (see text-books), which however is admirably suited to xerophytic plants, under which class most

C. come. Living in cold soil, as most of them do, and often with evergreen leaves, it is obviously a necessity to reduce transpiration (see p. 164).

When we turn to the flr., we are met with great difficulties. There are two great rival theories about its morphology, those of Eichler (*Blüthendiag.* or *Nat. Pfl.*) and of Celakovsky (see Warming's *System. Bot.* or *Bot. Jahresb.* 1890, p. 324, also Noll in *Bot. Centr.* 60, p. 131). It would be inconsistent with the plan of this work to enter into a discussion of these; we shall merely state both of them. As the order is usually classified according to the Eichlerian view, we have adopted his theory in the classification and in the details of the genera, without however intending thereby to express any judgment upon its correctness.

The flrs. of C. appear as a rule in the form of *cones*, and are always unisexual, mon- or di- œcious. They are never terminal on the main stem as in Cycads, but are usually borne laterally near to its apex. Sometimes (as in Pinus ♂) the cones are massed together in spikes or heads.

Both theories above mentioned agree about the male flr., which is usually a cone or catkin of sta. borne on a central axis. The sta. may be flat, but is commonly more or less peltate, and bears a number of pollen-sacs (not more than 9 as a rule) on its lower surface (see Pinus, Taxus &c.). Turning now to the female, the cone (to avoid for the present the word flower) consists typically of an axis bearing leaf-like organs. The most familiar case is that of Pinus (*q.v.*), where each leaf borne on the axis is a small scale, bearing on its upper surface a very large scale (these latter show on the outside of the cone) on the upper side of which, again, are the two ovules. We may diagrammatically represent it thus, using "cover-scale" to express the lower, "ovuliferous scale" to express the upper, of the two scales. Turning to Cryptomeria etc. we find a large scale borne directly on the axis, with a little flap on its upper side near the outer end, and the ovules at the base. The flap is, by both theorists, supposed to represent the ovuliferous scale and so we have what is illustrated by the second diagram. Then in *Cupressineae* etc. we find only one scale, and here the two theorists differ. In the other order, *Taxaceae*, still further difficulties meet us. In Microcachrys the ovule is borne upon a leaf of the cone, but in Phyllocladus it is axillary and in Taxus terminal (see these genera and Ginkgo). In most C. there is only one integument, but in *Taxaceae* a second commonly appears, forming an aril, more or less fleshy, round the seed as it ripens.

| cover-scale
| ——
| ovules
| ovulif. scale
| cover-scale
| ——
| ovules

| ovulif. sc } cover-scale }
| ——
| ovules
| ovulif. sc } cover-scale }
| ——
| ovules

Now as to the explanation of the facts. Eichler regards the whole cone as one female flr. with a number of cpls. (the 'cover-scales'). The cpl. may bear the ovule directly, as in the latter cases above mentioned, or may develope upon its upper surface a placenta (ovulif. scale) which bears the ovules. Cryptomeria thus represents a stage in this evolution, and the whole may be compared with the division of a leaf into a sterile and fertile part, as in Ophioglossum. The rival theory of Celakovsky regards each ovule or pair of ovules with its appurtenances as a female flr. (one cpl. to each ovule) so that the cone is a spike of flrs. A series may be thus drawn: Ginkgo (♀ flr. of two cpls. each with one ovule); Podocarpus (one cpl., one ovule with two integuments, the whole in the axil of a cover-scale, which is therefore to be regarded as a *bract*), Taxus (flr. reduced to ovule, aril = outer integument; then in the *Araucariaceae* we have spikes of flrs. (cones), the cover-scale being the bract, the ovuliferous scale the combined outer integuments of the ovules of two cpls. (or three, the keel on the middle of the scale in Pinus etc. representing the third): a fusion of the bract with the flr. in its axil is supposed to have gone on, and we get next the Cryptomeria type, and finally that of *Cupressineae*.

The ovules are orthotropous, except in Podocarpus. The processes of development of the ovule, fertilisation, &c., must be studied elsewhere (see arts. *Pinus*, *Gymnospermae*). The cone often becomes hard and woody as the seeds ripen, whilst in other cases it becomes fleshy. The seeds contain an embryo with 2—15 cotyledons, and rich endosperm.

Natural History. The C. are entirely wind-fertilised; the pollen is light and powdery, sometimes provided with air-bladders (*e.g.* Pinus), and is produced in enormous quantities. About the time it is shed the scales of the female cones open to receive it and the grains adhere to the sticky fluid at the apex of the ovule. Fertilisation often does not take place for a long time afterwards (see Pinus and Ginkgo).

The seeds in many genera with woody cones (*e.g.* Pinus) are winged for wind-carriage; in other genera they are animal-distributed, *e.g.* Juniperus (cone fleshy), Taxus (fleshy aril), &c.

Further details of the morphology, life history, &c. will be found under the headings *Gymnospermae*, *Pinus* and others of the genera. See also art. *Retinospora*, where the peculiar case of plants retaining the 'seedling' form throughout life is dealt with.

Economically the C. are a most important class, furnishing a large proportion of our timber, as well as resins, tars, turpentines, &c. See genera, especially Abies, Pinus, Larix, Tsuga, Libocedrus, Juniperus, Taxus, &c.

Classification and Key to Genera (after Eichler and Engler):

N. O I. ARAUCARIACEAE (Pinoideae). Cones perfect; seeds concealed between scales; testa woody or leathery; no aril.

1. *ABIETINEAE.* Leaves spirally arranged. Ovule usually reversed (micropyle facing axis).

1 a. *Araucariinae* (cpl. simple; 1 ovule, reversed, on middle line).

1 b. *Abietinae* (cpl. + ovulif. scale, the latter large; ovules 2, reversed).

1 c. *Taxodiinae* (cpl. + ovulif. scale, or with swelling on inner side; ovules 2—8, axillary and erect (i.e. with micropyle away from axis), or on surface of cpl. and reversed).

2. *CUPRESSINEAE.* Leaves (incl. those of cone) opp. or whorled, rarely alt. Ovules erect.

2 a. *Actinostrobinae* (cone woody when ripe; cpls. valvate).

2 b. *Thujopsidinae* (cone woody when ripe; cpls. imbricate; whorls of all flrs. 2-merous).

2 c. *Cupressinae* (cone woody when ripe; cpl. peltate; whorls of all flrs. 2-merous).

2 d. *Juniperinae* (cone berry- or drupe-like when ripe).

N. O. II. TAXACEAE (Taxoideae). Cone-formation imperfect; seeds projecting beyond cpls. or even naked. Seed with fleshy aril or drupaceous testa.

3. *PODOCARPEAE.* Seeds more or less reversed. Cpls. always present, 1-seeded.

4. *TAXEAE.* Seeds erect. Cpls. sometimes wanting.

Key to Genera.

1. *ABIETINEAE:*

1 a. *Araucariinae:*

Seeds free from cpl. — 1. Agathis.
,, united to ,, — 2. Araucaria.

1 b. *Abietinae:*

A. Long and short shoots both present.
a. Long shoots with scale leaves only; the green (needle) leaves on the short shoots. — 3. Pinus.
b. Needle leaves on both shoots:
α. Needles evergreen: fruit 2—3 years in ripening. — 4. Cedrus.
β. Deciduous: fruit 1 year in ripening.
I. Cone-scales persistent. — 5. Larix.
II. ,, deciduous. — 6. Pseudolarix.

B. Shoots of one kind only (long):
a. Needles 4-angled. Cone pendulous. Scales persistent. — 7. Picea.
b. ,, flat. Otherwise as a. — 8. Tsuga.
c. ,, ,, Cone erect with deciduous scales. — 9. Abies.

1 c. *Taxodiinae:*

A. Long shoots with scale-leaves, and short shoots = double needles. — 10. Sciadopitys.

B. Long shoots only.
a. Seed reversed.
α. Cpl. with narrow scale, transverse, above seed. 11. Cunninghamia.
β. Cpl. with ridge-like inner scale. Tasmania. 12. Arthrotaxis.
γ. Cpl. shield-shaped, no distinct scale. N. Am. 13. Sequoia.
b. Seed erect.
α. Cpl. with toothed scale. 14. Cryptomeria.
β. Cpl. shield-shaped, no distinct scale.
I. Cone-scales persistent. N. Am. 15. Taxodium.
II. ,, deciduous. China. 16. Glyptostrobus.

2. *CUPRESSINEAE:*
2 a. *Actinostrobinae:*
A. Cone with involucre of several whorls of scale-leaves. Whorls 3-merous. 17. Actinostrobus.
B. No involucre. 2- 3- or 4-merous. Valvate. 18. Callitris.
C. Transition form to preceding. Cpls. slightly imbricate. 2- 3-merous. 19. Fitzroya.
2 b. *Thujopsidinae:*
A. Cpl. with 4—5 seeds. 20. Thujopsis.
B. ,, ,, 2 (1—3) seeds.
a. Cpls. 4, the upper pair fertile. 21. Libocedrus.
b. ,, 6—8, both upper pairs fertile. 22. Thuja.
2 c. *Cupressinae:*
A. Cpls. many-seeded. 23. Cupressus.
B. ,, 2-seeded. 24. Chamaecyparis.
2 d. *Juniperinae:*
Only genus. 25. Juniperus.

3. *PODOCARPEAE:*
A. Seeds quite reversed, almost or quite concealed between the scales of the (when ripe) fleshy cone. Aril short.
a. Cpls. united when ripe. Monœcious. Needle leaves. 26. Saxegothæa.
b. Cpls. free. Diœcious. Leaves scale-like. 27. Microcachrys.
B. Seeds anatropous, projecting beyond cpls. Aril developed as a complete outer integument. 28. Podocarpus.
C. Transition to preceding. Seeds inserted on lower half or in angle of cpl., little or not at all reversed. 29. Dacrydium.

4. *TAXEAE:*
A. Long and short shoots, the latter phylloclades. 30. Phyllocladus.

B. Long and short shoots, of usual form. Leaf like that of maiden-hair fern. 31. Ginkgo.

C. Long shoots only.

a. Cpls. present, but aborting as they ripen, each with 2 ovules. 32. Cephalotaxus.

b. Cpls. absent; ♀ flower reduced to a naked ovule.

α. Flr. shoots with 2 ovules. Sta. with 4 pollen sacs. 33. Torreya.

β. „ „ 1 ovule. Sta. with 6—8 pollen sacs. 34. Taxus.

Conium Linn. Umbelliferae (5). 2 sp. Eur., As., Afr. *C. maculatum* L. (hemlock) in Brit. It is very poisonous.

Connaraceae. Dicotyledons (Archichl. Rosales). 16 gen. with 160 sp.; they are closely allied to Leguminosae, being chiefly distinguished by the absence of stipules and the (usual) presence of more than two free cpls. They are mostly twining shrubs with alt. exstip. leaves and panicles of regular flrs. K 5, imbricate or valvate; C 5; A 10 sometimes joined below; $\underline{G}$ 5 or 1 or 4, each with 2 erect orthotropous ovules. Fruit usually one follicle with one seed, albuminous or not, arillate. *Chief genera:* Connarus, Rourea, Cnestis. Placed in Rosales by Benth.-Hooker, in Terebinthinae by Warming.

Connarus Linn. Connaraceae. 50 sp. trop. Am., Afr., As.

Conocephalus Blume. Moraceae (III). 10 sp. Indo-mal. The leaves of *C. suaveolens* Blume possess water-secreting glands (p. 114).

Conopodium Koch. Umbelliferae (5). 12 sp. Eur., As., N. Afr. *C. denudatum* Koch (*Bunium flexuosum* With.) in Brit. (earth nut). The tuberous roots are edible when roasted.

Conospermum Sm. Proteaceae (I). 33 sp. Austr. *C. Stoechadis* Endl. has been suggested as a useful plant to introduce into desert regions. "All kinds of pasture animals browse with avidity on the long, tender, and downy flower-stalks and spikes, without touching the foliage" (F. von Mueller).

Conostylis R.Br. Amaryllidaceae (III). 32 sp. W. Austr. [Haemodoraceae, Benth.-Hooker.]

Convallaria Linn. Liliaceae (VII). 1 sp. N. temp. (incl. Brit.), *C. majalis* L., the lily of the valley, which occurs in woods. The stock developes a few scales and two green leaves annually. The flrs. are homogamous and fertilise themselves in absence of insects.

Convallariaceae (Warming) = Liliaceae (suborders VI—XI).

Convolvulaceae. Dicotyledons (Sympet. Tubiflorae). About 40 gen. with 1000 sp. trop. and temp. Many are annual herbs, others shrubs or (rarely) trees. Several are thorny xerophytes, many are climbing herbs or lianes, and one (Cuscuta) is a climbing parasite. Some have tuberous roots (e.g. *Ipomoea Batatas*), others rhizomes or tuberous stems. Latex is often present. Leaves alt., usually petiolate, rarely with stipules. Accessory buds are often found in the leaf-axils.

Infl. dichasial with tendency to cincinnus or bostryx; bracts and bracteoles present.

Flr. ☿, regular, hypogynous, usually 5-merous. K usually polysepalous, imbricate, the odd sepal posterior; C sympetalous, of various shapes, usually induplicate-valvate, sometimes convolute; sta. 5, alternating with pets., epipetalous, on base of corolla, with usually introrse anthers. Ovary on a honey-secreting disc, of 2 cpls. (rarely 3—5), syncarpous with axile placentae; ovules 2 in each loc. (rarely 4), erect, anatropous or semi-anatropous, the micropyle facing outwards and downwards; one integument. Berry, nut or capsule; seeds albuminous.

The flrs. are usually large and brightly coloured and are visited by insects. Extra-floral nectaries are found in many sp. on the petiole. Few are of economic value except for their handsome flrs. (see Ipomoea).

The C. are closely related to Solanaceae, Boraginaceae and other Tubiflorae. See *Nat. Pfl.* and esp. note by Engler at p. 1 of art. C.

Classification and Chief Genera (after Peter):

I. *CONVOLVULOIDEAE* (independent green plants):

1. *Dichondreae* (ovary usually divided, with 2 gynobasic styles; fruit like Labiatae): Dichondra, Falkia (only genera).
2. *Dicranostyleae* (ovary not divided; styles 2, or 1 bifid; flr. 5-merous): Dicranostyles, Evolvulus.
3. *Hildebrandtieae* (as 2, but 4-merous; 2 outer sepals large in fruit, united to peduncle): Hildebrandtia (only gen.).
4. *Convolvuleae* (as 2, but style undivided): Porana, Ipomoea, Convolvulus.
5. *Erycibeae* (style very short; corolla lobes deeply bifid; berry; one seed): Erycibe (only genus).

II. *CUSCUTOIDEAE* (leafless saprophytes; embryo without cotyledons): Cuscuta (only genus).

[Placed in Polemoniales by Benth.-Hooker, in Tubiflorae by Warming.]

Convolvulus (Tourn.) Linn. Convolvulaceae (I. 4). 160 sp. chiefly temp. *C. arvensis* L. in Brit. (bindweed). It has sweetly scented flrs. which are much more often visited by insects than the large but scentless flrs. of *Calystegia sepium*. Smaller flrs. with short sta. appear on some stocks; these appear to be due to the action of a fungus (cf. Lychnis and see *Beih. z. Bot. Centr.*, 1893, p. 447). The root produces adventitious stem buds, by which vegetative multiplication takes place to a large extent. From incisions made in the rhizome of *C. scammonia* L. a resinous juice flows, which is used in medicine as a purgative (Scammony).

Conyza Linn. Compositae (III). 50 sp. temp. and subtrop.

Cooperia Herb. Amaryllidaceae (I). 2 sp. Mexico, Texas.

Copaiba Adans. = Copaifera Linn.

Copaifera Linn. Leguminosae (II. 2). 16 sp. trop. Am., Afr. Several

S. Am. sp. yield the resin known as Balsam of Copaiba, and resins (copals) are also obtained from the Afr. sp.

Copernicia Mart. Palmae (I. 2). 6 sp. Am. *C. cerifera* Mart. is the wax- or Carnauba-palm of Brazil. Its leaves are coated with wax, which can be removed by shaking; it is used in making candles and is largely imported into Brit. The wood, leaves, &c., are also useful.

Coprosma Forst. Rubiaceae (II. 17). 40 sp. N. Z., Austr., Malaya, Chili. The stipules of some sp. are glandular, and some have peculiar openings (?domatia) on the backs of the leaves.

Coptis Salisb. Ranunculaceae (2). 8 sp. N. temp. and arctic.

Corallorhiza Hall. Orchidaceae (8). 12 sp. N. temp. *C. innata* R. Br. (coral-root) in Brit. Saprophytes with much branched fleshy rhizome, no roots, and scaly leaves. [See p. 177, and cf. Epipogum.]

Corchorus (Tourn.) Linn. Tiliaceae. 30 sp. trop. *C. capsularis* L. and *C. olitorius* L. (India &c.) furnish the chief supply of the valuable fibre jute or gunny (obtained by steeping the full-grown stems in water; cf. Linum). Annual plants about 12 feet high, little branched.

Cordia Linn. Boraginaceae (I). 230 sp. trop. Trees or shrubs. The fruit is edible; that of *C. Myxa* L. (Egypt to Austr.) was formerly used in medicine. [See Mez in *Engler's Jahrb.* XII.]

Cordiaceae (Warming) = Boraginaceae (suborder I).

Cordyline Comm. Liliaceae (VI). 10 sp. trop. and warm temp. Favourite decorative plants with the habit of Dracaena. The leaves of some sp. yield fibre.

Coreopsis Linn. Compositae (V). 70 sp. Am., trop. Afr., Sandw. Is.

Corethrogyne DC. Compositae (III). 3 sp. Calif.

Coriandrum (Tourn.) Linn. Umbelliferae (8). 3 sp. Medit. The fruits (Coriander-seeds) of *C. sativum* L. are used in flavouring.

Coriaria Niss. ex Linn. The only genus of Coriariaceae. 8 sp. Medit., India to Japan, N. Z., Chili to Mexico. The genus is thus probably one which was formerly very widely spread over the globe (p. 146). They are mostly shrubs with opp. or whorled leaves, sometimes becoming alt. at the ends of the shoots. The inconspicuous protogynous flrs. are borne in racemose infls. K 5, C 5, A 5 + 5, $\underline{G}$ 5. The petals are keeled on the inner side, and after fertilisation of the flr. grow fleshy and enclose the cpls. forming a pseudo-drupe. Ovules 1 in each loc., pendulous, anatropous; raphe dorsal. Endosperm thin.

Coriareae (Benth.-Hooker) = Coriariaceae.

Coriariaceae. Dicotyledons (Archichl. Sapindales). Only genus Coriaria (*q.v.*). The only nearly related order is Empetraceae. Placed as anomalous order at end of Disciflorae by Benth.-Hooker.

Coris Tourn. Primulaceae (V). 2 sp. Medit.

Corispermum B. Juss. ex Linn. Chenopodiaceae (6). 10 sp. N. temp.

Cornaceae. Dicotyledons (Archichl. Umbelliflorae). 16 gen. with 80 sp., cosmop., but chiefly N. temp. Shrubs with opp. or rarely alt. leaves, usually entire, exstip. Infl. dichasial, usually condensed into corymb or umbel form, or even (Cornus) into heads with involucres. Flrs. usually ☿, regular, 4—5—∞-merous. Typical formula K 4, C 4, A 4, $\overline{G}$ (2). There is an epigynous disc, and a simple style with lobed stigma. Ovary multi-loc., with usually 1 pendulous ovule in each loc., the raphe of the ovule dorsal. Fruit a berry or more often a drupe, with a 1—4-loc. stone or 2 separate stones. *Chief genera:* Cornus, Garrya, Aucuba.

Cornucopiae Linn. Gramineae (VIII). 1 sp. Orient., *C. cucullatum* L. Flrs. in small heads; when the fruit is ripe these bend over and break off with a sharp point. They adhere to animals and are also said to burrow into the soil (cf. Stipa).

Cornus (Tourn.) Linn. Cornaceae. 25 sp. Eur., As., Am. 2 in Brit., *C. sanguinea* L. the cornel or dogwood, and *C. suecica* L. The flr. of the former is biologically like that of an Umbellifer, but is homogamous. Its berry fruits are eaten by thrushes. The latter is a dwarf herbaceous perennial, common in the Highlands. Annual stems are given off from the creeping perennial stems. Flrs. in umbels with involucres of 4 large white bracts. *C. florida* L. (N. Am.) and others yield useful wood. *C. mas* (*mascula*) L., the Cornelian cherry (Eur., As. Minor), yields a fruit which makes good preserves. Its flrs. appear in spring before the leaves (p. 103).

Coronarieae (Benth.-Hooker). The 3rd series of Monocotyledons.

Coronilla Tourn. ex Linn. Leguminosae (III. 7). 20 sp. Eur., Medit., W. As. The flr. resembles that of Lotus, but the honey (at least in *C. varia* L. and others) is secreted by the outer surface of the calyx, and insects poke their tongues through between the claws of the petals, which are longer than usual. The buds are bent downwards, the open flrs. project horizontally, the ripening fruits downwards and the ripe fruits usually upwards (p. 104).

Coronopus Rupp. ex Linn. = Senebiera DC.

Correa Andr. Rutaceae (III). 5 sp. temp. Austr. Favourite greenhouse shrubs. Flr. sympetalous.

Corrigiola Linn. Caryophyllaceae (II. 4). 6 sp. Medit., Eur. *C. littoralis* L. on coasts of Devon and Cornwall.

Cortusa Linn. Primulaceae (I). 1 sp. Mts. of Eur. and As.

Coryanthes Hook. Orchidaceae (19). 4 sp. trop. S. Am., epiphytic. One of the most remarkable flrs. in existence. The flr. is pendulous; the sepals are bent back and fairly large, the petals small. The labellum is of a most complex shape; projecting horizontally from the base of the column is a bar bearing a dome on the end, from which is suspended a bucket-like organ; the mouth of the bucket faces upwards, and the edges are incurved; there is also an overflow-pipe projecting towards the sepals and closely covered in by the bent end of the column, with the stigma and anther. From the base of the column project two horns which secrete a thin watery fluid that drips into the bucket, keeping it full to the level of the overflow pipe.

The dome (above) is composed of succulent tissue very attractive to bees; these fight for places on it whence to drill the tissue; every now and then one of them gets pushed off and falls into the bucket. It can neither fly nor climb out, and so has to squeeze through the overflow pipe. In so doing it first passes the stigma, fertilising it if it bears any pollen, and then, passing the anther, is loaded with new pollinia to be transferred to other flrs. "I have often seen this, and sometimes there are so many of these humble bees assembled that there is a continual procession of them through the passage" (Crüger). [See Darwin's *Orchids*, p. 173, and cf. Stanhopea.]

Corydalis Vent. Papaveraceae (III). 90 sp. Medit., Eur., As. *C. claviculata* DC. in Brit., a (leaf) tendril-climbing annual. Most are perennial herbs with underground tubers. In *C. cava* Schweigg. and Kort., and other sp. the main axis forms a tuber, which dies away below, each annual shoot arising from the axil of a scale-leaf of older date. In *C. solida* Sw., and others, the tuber is a swollen root-structure belonging to the current annual shoot. Flr. transversely zygomorphic (see order for diagram); only one petal is spurred and contains the honey secreted by a staminal outgrowth. Twisting of the axis through 90° brings the flr. into a vertical position. Its mechanism resembles that of many Leguminosae. The inner petals, united at the tip, enclose the stigma and anthers; the upper petal covers the flr. Bees alighting push down the inner petal and cause the essential organs to emerge. In some sp., *e.g.* *C. ochroleuca* Koch and *C. lutea* DC., the emergence is explosive (cf. Genista). The flrs. of *C. cava* are self-sterile (p. 95).

Corylopsis Sieb. et Zucc. Hamamelidaceae. 6 sp. China, Japan. Flrs. ☿, in spikes with coloured bracts at base.

Corylus (Tourn.) Linn. Betulaceae. 7 sp. N. temp. *C. Avellana* L., the Hazel-nut (Brit.) is the most familiar. The general habit is shrubby (largely owing to the extensive formation of suckers), with catkinate flrs. (the ♀ catkin sessile and elliptical in outline, rather resembling a bud). Both are laid down in autumn; the ♂ catkins are visible all winter on the bushes, but the ♀ are not obvious until the red stigmas come out early in the year. Like other catkinate plants they are anemophilous, and the fact of flowering before the appearance of the leaves renders their chance of fertilisation much greater. On the inner side of the bract in the ♂ catkin are found 2 scales and, adnate to these, 4 sta., each branched nearly to the base. There is present here only the central flr. of the possible 3 (cf. diagram of order), with its bracteoles α, β. In the ♀ catkin, on the other hand, we have the two laterals and not the central flr. as shown in the diagram overleaf (* = missing flr.). At the time of fertilisation, the ovary is very minute, but the long red stigmas are easily identified. After fertilisation, the ovary (2-loc.

stem
* ♂ flr. *
α β
bract

at first) gives a one-seeded nut, enclosed in a cup of green leafy nature, which is really the combined bract and bracteoles α, α', β', very much developed. The flr. is chalazogamic (see art. *Chalazogamae*). The nuts of this and other sp. are valuable as dessert fruit &c. (hazel-nut, cob-nut, filbert). The wood is elastic, but cannot be obtained in large boards. Oil is expressed from the seeds.

stem
α' α'
α ♀ flr. ✻ ♀ flr. β
β' β'
bract

Corynephorus Beauv. (*Weingaertneria* Bernh.). Gramineae (IX). 3 sp. Eur. *C. canescens* Beauv. (*W.* or *Aira canescens*) in Brit.

Corypha Linn. Palmae (I. 2). 6 sp. Ceylon, Indo-mal. The infl. terminates the life of the tree and is of gigantic size. *C. umbraculifera* L. is the Talipot palm of Ceylon; it grows to a great size (up to 100 feet in height). The leaves are used as umbrellas, and for thatching, also as writing material (a metal stylus being used).

Cosmanthus Nolte = Phacelia Juss.

Cosmibuena Ruiz et Pav. (1802). Rubiaceae (I. 4). 6 sp. trop. Am. There is good bud-protection by means of the stipules of the last-opened leaves.

Cosmibuena Ruiz et Pav. (1794) = Hirtella Linn. (Rosaceae.)

Cosmos Cav. (*Cosmea* Willd.). Compositae (V). 20 sp. Am.

Costus Linn. Zingiberaceae. 25 sp. trop. Am., W. Afr., As., Austr. The labellum is very large, the lateral staminodes wanting, the sepals and petals comparatively small. Projecting in the centre of the flr. is the fertile petaloid sta. with the anther on its anterior face; the style reaches just above this. The floral mechanism thus resembles that of Iris.

Cotinus (Tourn.) Linn. = Rhus Linn. *C. coggygria* Scop. = *R. Cotinus*.

Cotoneaster Rupp. Rosaceae (II. 4). 30 sp. N. temp. *C. vulgaris* Lindl. was till lately found on the Great Orme's Head near Llandudno, but is now extinct in Brit. In the Alps the flr. is visited solely by a wasp (*Polistes gallica*) whose nests are often found attached to the rocks where the plant is growing. The flr. is protogynous with self-fertilisation in default of insect visits. Several sp. are favourites in shrubberies &c.

Cotula (Tourn.) Linn. (excl. *Cenia* Juss.). Compositae (VII). 50 sp. S. Hemisph., Medit., As., N. Am.

Cotyledon Tourn. ex Linn. (incl. *Echeveria* DC.). Crassulaceae. 90 sp. Afr., Eur., As., Mexico, S. Am. *C. Umbilicus* Linn. (penny-wort) in Brit. Petals united into a tube. Leaves succulent. [*Linn. Soc. Journ.* XXX. p. 292.]

Coumarouna Aubl. = Dipteryx Schreb.

Couratari Aubl. Lecythidaceae. 8 sp. S. Am. The bark yields a soft fibre used for making clothing.

Couroupita Aubl. Lecythidaceae. 9 sp. trop. S. Am. The flrs. of *C. guianensis* Aubl., the commonest sp., are borne on the old stems

(p. 156), and followed by large spherical woody capsules (whence the name of cannon-ball tree).

Cousinia Cass. Compositae (XI). 210 sp. Orient. (p. 194).

Crambe Tourn. ex Linn. Cruciferae (II. 10). 20 sp. Eur., Medit., As., Polynes., Patagonia. *C. maritima* L. (sea-kale) on the coast of Brit. Its leaves are fleshy and coated with wax (p. 186). The young leaves, blanched by tying them together, form a favourite vegetable.

Crantzia Scop. = Alloplectus Mart.

Crassula Dill. ex Linn. (excl. *Dinacria* Harv., and *Tillaea* Michx.). Crassulaceae. 100 sp. S. Afr., a few Abyss. and Himal. Chiefly succulent-leaved xerophytes. In *C. lycopodioides* Lam. the leaves are narrow and closely packed, giving to the plant the habit of a Lycopodium. In *C. falcata* Wendl. (*Rochea falcata* DC.) the connate decussate leaves stand almost edgewise. They are very fleshy and have a peculiar covering upon the surface; some of the epidermal cells are swollen above the rest into large bladders which meet one another over the whole surface. At first these are living and contain water, but when the leaf is mature they are dead and full of air, whilst their walls are infiltrated with quantities of silica. An effective protection against excessive evaporation is thus afforded. In *C. nemorosa* Endl. there is vegetative reproduction (p. 113) by the formation of young plants in the infl. in place of flrs.

Crassulaceae. Dicotyledons (Archichl. Rosales). 15 gen. with 450 sp. cosmop., but chiefly in S. Afr. They form a very natural group. Most are perennials living in dry (especially rocky) places and exhibit xerophytic characters, fleshy leaves and stem, often tufted growth, close packing of leaves upon one another, waxy surface, sunk stomata, &c. (see p. 165). Vegetative reproduction is frequent; it is usually effected by means of rhizomes or offsets; some sp. form bulbils, &c. (e.g. Crassula), others form adventitious buds upon the leaves (e.g. Bryophyllum). Flrs. usually in cymes (cincinni), ☿ or rarely unisexual, actinomorphic with very regular construction. The formula may be thus given, Kn, Cn, A$n+n$, $\underline{\mathrm{G}}n$, where n represents any number from 3 to 30. Calyx persistent. Corolla sometimes (e.g. Cotyledon) gamopetalous. Sta. frequently obdiplostemonous. The insertion of parts is usually perigynous, but the receptacle is not deeply hollowed. Cpls. frequently slightly united at the base. At the base of each there is commonly a honey-secreting scale. Ovules usually ∞. Fruit usually a group of follicles with very small seeds. Endosperm none or very little. The flrs. are mostly protandrous and chiefly visited by flies, &c., their honey being easily obtainable. The *chief genera* are thus grouped by Schönland (in *Nat. Pfl.*) around Sedum:

$$\text{Sedum}\begin{cases}\text{Sempervivum}\\ \text{Cotyledon} \rightarrow \text{Bryophyllum}\\ \text{Crassula}\end{cases}$$

[Placed in Rosales (Benth.-Hooker); Saxifraginae (Warming).]

Crataegus Tourn. ex Linn. [United to *Mespilus* in *Nat. Pfl.* The boundaries of these two genera and of *Pyrus* are ill-defined.] Rosaceae (II. 4). About 60 sp. N. temp. *C. Oxyacantha* L. (hawthorn or may) in Brit. The thorns are modified branches. The wood is regarded as a good substitute for that of box in engraving &c.

Crataeva Linn. Capparidaceae (III). 10 sp. trop.

Cratoxylon Blume. Guttiferae (II). 12 sp. Indo-mal.

Crepis (Vaill.) Linn. (incl. *Barkhausia* Moench). Compositae (XIII). 170 sp. N. Hemisph. 6 in Brit. (hawk's beard). Like Hieracium.

Crescentia Linn. Bignoniaceae (IV). 5 sp. trop. Am. The flrs. are borne on old stems (p. 156) and are succeeded by the gourd-like berries. The epicarp is woody and after removal of the pulp forms a useful calabash (*C. Cujete* L., the calabash tree, is most used).

Crinum Linn. Amaryllidaceae (I). 70 sp. trop. and sub-trop., chiefly on sea-coasts. Large and handsome bulbous plants with showy flrs. (? visited by humming-birds). The seed of *C. asiaticum* L., according to Goebel (*Pflanzenbiol. Schild.* I. p. 128), has only a very thin corky covering and is adapted to distribution by water and early germination. The ovule has no integuments, and the want of a testa is replaced by a formation of cork at the outside of the endosperm.

Cristaria (Heist.) Cav. Malvaceae (II). 25 sp. Chili, Peru.

Crithmum Linn. Umbelliferae (6). 1 sp., *C. maritimum* L., the samphire, on rocky coasts, Medit., Eur. (incl. Brit.). It has much divided and very fleshy leaves (p. 186). It is used for making pickles.

Crocosmia Planch. Iridaceae (III). 1 sp., *C. aurea* Planch., trop. and S. Afr. United to Tritonia in *Nat. Pfl.*

Crocus (Tourn.) Linn. Iridaceae (I). 60 sp. Medit., Eur., 2 sp. naturalised in Brit. Below ground is a corm, covered with a few scaly leaves, in whose axils may arise one or more buds, giving rise to new corms on the top of the old. The leaves are dorsiventral, and curiously grooved on the back. The flr. is often single and terminal; in some sp. there is a small cyme of flrs. The tube of the perianth is so long that the ovary remains below the soil and is thus protected from the weather (cf. Colchicum). The flr. is protandrous and visited by bees and Lepidoptera. Honey is secreted by the ovary, and the anthers face outwards so as to touch any insect alighting on the petals and seeking honey. The stigmas are branched. Birds often bite off the flrs. in gardens (? for honey); they seem to prefer the yellow flrs., leaving the blue and white alone. [See Schumann in *Bot. Zeit.* 1894.]

The dried stigmas of *C. sativus* L. form saffron, once largely used as an orange-yellow dye, but now chiefly employed in flavouring and colouring dishes, liqueurs, &c. [See Kronfeld's *Geschichte des Safrans* &c., Wien 1892, or *Beih. z. Bot. Centr.*, 1893, p. 71.]

Crossandra Salisb. Acanthaceae (IV. B). 17 sp. trop. As., Afr., Madag. The seeds of many sp. are covered with scales which spread out and become sticky when wetted, thus anchoring them to suitable places for germination (cf. Linum).

Crotalaria Dill. ex Linn. Leguminosae (III. 3). 250 sp. trop. and sub-trop. *C. juncea* L. (India, Austr.), an annual plant growing about 8 ft. high, is largely cultivated for the fibre obtained from its stems by maceration in water (cf. Linum), and known as Sunn-hemp, Bombay or Madras hemp, &c. *C. retusa* L. (trop.) is also employed and probably other sp. would be found useful.

Croton Linn. Euphorbiaceae (A. II. 1). 600 sp. trop. Flrs. mon- or di-œcious, comparatively little reduced in structure from the primary type of the order. *C. Tiglium* L. (trop. As.) is the source of croton oil (a very powerful purgative drug, expressed from the seeds). *C. Cascarilla* Benn. yields Cascarilla bark, used as a tonic (see Cascarilla). *C. lacciferus* L. (India, Ceylon), yields a lac-resin, used in varnish-making.

Crucianella Linn. Rubiaceae (II. 21). 4 sp. Eur., Medit. For *C. stylosa* of gardens see Phuopsis.

Cruciferae. Dicotyledons (Archichl. Rhœadales). About 200 gen. with 1200 sp., cosmop., but chiefly N. temp. and esp. Medit. They form a very natural family, well marked off from all others, though approaching nearly to Papaveraceae and Capparidaceae. Most are herbs, a few undershrubs; some annuals, many perennials, forming each year a new shoot terminating in the infl. Leaves usually alt., exstip., with unicellular simple or branched hairs. For other peculiarities of the vegetative organs see genera, *e.g.* Brassica, Anastatica, Subularia, Vella, &c. The infl. is usually a raceme or corymb, and nearly always without either bracts or bracteoles.

Flr. usually ☿, regular, hypogynous, with typical formula K 2 + 2, C 4, A 6, $\underline{G}$ (2). The calyx has two whorls, the corolla only one, alternating with the calyx as a whole. The petals usually spread out in the form of a cross and are often clawed. The sta. are in two whorls, an outer of 2 short, an inner of 4 long, sta. (tetradynamous); anthers introrse. The two cpls. are placed transversely, and have parietal placentae, but the ovary is 2-loc. on account of the presence of an antero-posterior partition, the *replum* or so-called spurious septum, an outgrowth of the placentae. Stigmas 2, on short style, above the placentae (cf. Papaveraceae). Ovules anatropous or campylotropous.

Floral Diagram (after Eichler).

The explanation of the morphology of this flr. has given rise to much dispute and no agreement has been arrived at. It is often regarded as a typically 2-merous flr. (cf. Papaveraceae), and the 4 petals and 4 inner sta. are supposed to be due to branching. Others again regard it as 4-merous (see e.g. Klein in *Bot. Centr.* 58, p. 197). A full discussion of the point may be found in Eichler's *Blüthendiagr.* or in Asa Gray's *Struct. Bot.* p. 206.

On the bases of the sta. are the nectaries, the honey being secreted into the often gibbous bases of the inner sepals. The sepals often stand almost straight up, and the petals are then provided with claws and spread out horizontally beyond the sepals. The honey is thus concealed to some extent and protected from rain. The majority of the order exhibit this construction more or less, thus coming into the biological group of flowers AB (see p. 90). In many genera the flrs. are arranged in corymbs, thus getting the advantage of many flrs. being massed together on one level (cf. Umbelliferae and Compositae). Insects visiting the flrs. touch the anthers with one side of their bodies and the stigma with the other, and may in this way effect cross-fertilisation, as they go sometimes to one, sometimes to the other, side of the flr. Dichogamy is frequent, but not well marked, and in almost all cases self-fertilisation ultimately occurs. [For details see Müller, *Fert. of Flrs.*]

The fruit is a capsule of pod-like form; if it be at least three times as long as it is broad it is called a *siliqua*, if shorter it is called a *silicula*. It is divided into two by the replum and is usually thin and membranous. Dehiscence occurs by the valves breaking away from below upwards, leaving the replum with the seeds pressed against it and adhering. The fruit may be flattened in two ways, either parallel to or at right angles to the replum; this character is of systematic importance. It may also be jointed between the seeds as in a lomentum (Leguminosae). Achene-like one-seeded fruits occur in a few genera. Others have subterranean fruits (Cardamine sp. &c.).

The characters of the seed are also of great importance in the classification of the order. The seed is exalbuminous: the testa is very often mucilaginous, swelling up when wetted (e.g. the familiar case of mustard seed); this property is valuable for fixing the seed in a favourable spot for germination. The ovules being campylotropous, the embryo sacs, and thus the embryos, are curved, usually with the radicle in one half of the seed, the cotyledons in the other. The shape of the embryo and the position of the radicle with regard to the cotyledons are of much importance. The chief cases are: (1) radicle *incumbent* (or embryo *notorhizal*) *i.e.* lying on the back of one cotyledon, the cotyledons not being folded on themselves; this may be shown thus o||, the o representing the radicle; (2) *accumbent* (or embryo *pleurorhizal*), o =, the radicle against the edges of the cotyledons; (3) *orthoplocous* (cotyledons *conduplicate*), o > >; (4) *spirolobous*, as in (1) but cotyledons once folded, o||||; (5) *diplecolobous*, ditto twice or more folded, o||||||.

For plants of economic value see especially Brassica, Nasturtium, Lepidium, &c. All C. are harmless, and most are rich in sulphur compounds (to which the smell of boiling cabbages is due), and are thus useful in scurvy &c.

Classification and chief genera (after Prantl):

The grouping of the smaller divisions of the order and the defining of the genera is a most difficult task. Many classifications have been devised. Prantl (in *Nat. Pfl.*) bases his largely upon the hairs borne on the leaves. Others rely on characters of fruit and embryo &c. In any case the identification of a cruciferous genus is a difficult matter; we shall not here go into the details of the classification, but merely give Prantl's groups and the chief genera belonging to them.

A. Hairs simple or none: no glandular hairs.

I. *Thelypodieae* (stigma equally developed all round; style undivided or prolonged above middle of cpls., or turned back).

1. Stanleyinae: Pringlea, Thelypodium.
2. Cremolobinae: Cremolobus.
3. Heliophilinae: Heliophila.
4. Chamirinae: Chamira.

II. *Sinapeae* (stigma better developed over placentae).

5. Lepidiinae: Subularia, Lepidium.
6. Cochleariinae: Iberis, Cochlearia.
7. Alliariinae: Alliaria.
8. Sisymbriinae: Sisymbrium, Cakile, Isatis.
9. Vellinae: Vella.
10. Brassicinae: Sinapis, Brassica, Crambe.
11. Cardamininae: Nasturtium, Cardamine.

B. Hairs branched (a few exceptions): sometimes also glandular hairs.

III. *Schizopetaleae* (stigma equal all round).

12. Schizopetalinae: Schizopetalum.
13. Physariinae: Physaria.

IV. *Hesperideae* (stigma better developed over placentae).

14. Capsellinae; Capsella, Draba.
15. Turritinae: Arabis.
16. Erysiminae: Erysimum, Cheiranthus.
17. Alyssinae: Alyssum.
18. Malcolmiinae: Anastatica, Malcolmia.
19. Hesperidinae: Hesperis, Matthiola.
20. Moricandiinae: Conringia.

[Placed in Parietales by Benth.-Hooker, in Rhœadinae by Warming.]

Cryptadenia Meissn. Thymelaeaceae. 5 sp. Cape Col.

Cryptanthus Otto et Dietr. Bromeliaceae (1). 6 sp. Brazil. Cultivated for their variegated leaves.

Cryptocarya R. Br. Lauraceae (11). 40 sp. trop. and subtrop. The fruits of *C. moschata* Nees et Mart. are known as Brazilian nutmegs, and used as spice.

Cryptocoryne Fisch. Araceae (VII). 20 sp. Indo-mal. Marsh plants. Some sp. are apparently 'viviparous' in their germination, like mangroves (p. 191, and see Goebel's *Pflanzenbiol. Schild.* I. p. 132).

Cryptogamae. A term used to distinguish those plants which are not Phanerogams, or in other words do not produce seeds. All the higher C. exhibit Alternation of Generations (see art. *Pteridophyta*), and the distinction between them and P. depends on the fact that in C. the *macrospore or spore falls out of its sporangium*, germinates upon the ground or in water and gives rise to an *independent* ♀ (or ☿) prothallus; in the P. (p. 56) on the other hand, the macrospore (embryo-sac) does not fall out of its sporangium (ovule) nor become independent. The result is the formation of a seed.

The C. are fertilised by aid of usually motile ♂ cells (anthero- or spermato-zoids) instead of the pollen-tubes of P.

The C. are divided into 3 great groups, Thallophyta, Bryophyta, and Pteridophyta, each usually regarded as equivalent to Phanerogams (see p. 124). With the first two groups this book does not deal. For further details of C. see Pteridophyta (where further references will be found) and Campbell's *Mosses and Ferns*.

Cryptogamae Vasculares = Pteridophyta.

Cryptogramme R. Br. (*Allosorus* Bernh.). Polypodiaceae. 1 sp. N. temp., esp. Alpine, *C. crispa* R. Br., the parsley fern or curled rock-brake, common in some districts of Brit.

Cryptomeria D. Don. Coniferae (Arauc. 1 c; see C. for genus characters). 1 sp., *C. japonica* D. Don (Japan, China), the Japanese cedar, often cultivated. The timber is valuable.

Ctenanthe Eichl. Marantaceae. 7 sp. trop. Am.

Cucubalus (Tourn.) Linn. Caryophyllaceae (I. 1). 1 sp. *C. baccifer* L., N. temp. (introd. in Brit.). Fruit a berry.

Cucumis (Tourn.) Linn. Cucurbitaceae (III). 26 sp. trop. and subtrop. *C. Melo* L. is the melon, *C. sativus* L. the cucumber, both cultivated from the earliest times. The tendrils are simple and are regarded as of leaf nature (see order), the stem portion being suppressed.

Cucurbita (Tourn.) Linn. Cucurbitaceae (III). 10 sp. Am., but many have been so long cultivated that their origin is doubtful. For the tendrils see order. Flrs. monœcious. The germination is interesting. On the lower side of the hypocotyl a peg is formed which holds one side of the testa firmly while the expansion of the plumule splits off the other side. The position of the peg is determined by gravity; if the seed be revolved on a klinostat during germination a ridge is formed all round the hypocotyl. Hence these seeds should always be sown with the flat surfaces horizontal.

C. Pepo L. is the pumpkin, with its varieties the vegetable marrow and squash; *C. maxima* Duchesne the giant pumpkin, largely cultivated in N. Am.

Cucurbitaceae. Dicotyledons (Sympet. Campanulatae). 87 genera with about 650 sp. found in most parts of the world, but wanting in the colder regions and most abundant in the tropics. They are chiefly climbing annual herbs with very rapid growth and great abundance of sap in their stems and other tissues. They climb by tendrils, about whose morphological nature there has been much discussion; for they have been considered by various authors as "roots, stems, leaves, stipules, shoots, flower-stalks or organs sui generis." According to Müller (*Nat. Pfl.*) the tendrils of *Cucurbita Pepo*, with their frequent abnormalities, give a proof of their true nature. Every variety is found, from simple threads to long leafy tendrils, in which the leaves show all transitions to tendrils. Müller, therefore, considers the twining portion of the tendril to be a metamorphosed leaf, the lower stiff portion a stem. The tendrils of C. are very sensitive and show very well all the phenomena of tendril-climbing.

The flrs. are diclinous, rarely ☿, in infls. of various types (see *Nat. Pfl.*, or Eichler, *Blüthendiagr.*).

The calyx and corolla are typically 5-merous, regular, with cohesion in both whorls. The sta. are typically 5, but great variety is introduced into the andrœceum by cohesions &c.; it is almost always zygomorphic. In Fevillea we find 5 sta. with bilocular anthers, the simplest type; it is noteworthy that the usual 4-locular anther never occurs in C., and no trace of the missing loculus is to be found in either lobe of the anther of Fevillea. In the rest of the order the andrœceum is more complex. In Thladiantha two pairs of sta. stand apart from the fifth sta. In Sicydium these pairs show union of their members at the base, and in others of the order the union is more complete, until, as in Bryonia &c., the andrœceum apparently has only 3 sta., of which 2 have 4-locular anthers. The more the sta. depart from the simple type the more curved do the loculi of the anthers become, till in Cucurbita &c. the pollen-sacs are twisted in a most extraordinary manner (cf. Columellia). In Cyclanthera the sta. are all united into a column with two ring-shaped pollen chambers running round the top (cf. the *flowers* of Cyclanthus).

The ovary is inferior, 1—10-loc., with 1—∞ anatropous ovules in each loc.; the most common type is, however, a 3-loc. ovary with axile placentae projecting deep into the cavity. Stigmas as many as cpls., usually forked.

Fruit nearly always fleshy, of the type exhibited in the melon or cucumber—a berry-like fruit, sometimes called a pepo. The seeds are exalbuminous. In Zanonia, Ecballium, Cyclanthera, &c. (q. v.), the mode of seed-dispersal is interesting.

The relationships of this order have been much disputed. Benth.-Hooker place it near Passifloraceae, Baillon near Loasaceae and Begoniaceae. It is now pretty generally accepted however that it comes near to the Campanulaceae, as here placed.

Many are valuable on account of their fruits, *e.g.* Cucurbita, Sechium, Luffa, Lagenaria, &c.

Classification and chief genera (after Pax):

A. Pollen-sacs not fused into a ring.

a. Sta. free or only united at base.

I. *Fevilleeae* (sta. 5, rarely 4): Fevillea, Zanonia, Thladiantha.

II. *Melothrieae* (sta. 3, rarely 2 or 4; pollen-sacs straight or slightly curved): Melothria, Telfairia.

III. *Cucurbiteae* (do., but pollen-sacs S or U shaped): Acanthosicyos, Momordica, Luffa, Bryonia, Ecballium, Cucumis, Lagenaria, Trichosanthes, Cucurbita.

b. Sta. united into a column.

IV. *Sicyoideae:* Echinocystis, Sechium, Sicyos.

B. Pollen-sacs fused into a ring.

V. *Cyclanthereae:* Cyclanthera (only genus).

Culcitium Humb. et Bonpl. Compositae (VIII). 14 sp. Andes. Like Espeletia (q. v.).

Cullenia Wight. Bombacaceae. 1 sp. India, Ceylon.

Cuminum (Tourn.) Linn. Umbelliferae (7). 1 sp., *C. Cyminum* L., Medit. The fruits are known as Cumin seeds, and are sometimes used like Caraway seeds.

Cunninghamia R. Br. Coniferae (Arauc. 1 c; see C. for genus characters). *C. sinensis* R. Br. the only sp., in S. China and Cochin-China.

Cunonia Linn. Cunoniaceae. 5 sp. New Caled., and *C. capensis* L. S. Afr. It shows good bud-protection by stipules (p. 155).

Cunoniaceae. Dicotyledons (Archichl. Rosales). 21 gen. with 120 sp., chiefly found between 13° and 35° S. Shrubs and trees with opp. or whorled leathery leaves, stipulate (the stipules often united in pairs as in Rubiaceae). Flr. small, usually ☿. Receptacle usually flat. K 4—5; C 4—5, usually smaller than calyx, often absent; A 8—10 or ∞ or 4—5; $\underline{G}$ usually (2), rarely 2. Ovary usually 2-loc., generally with ∞—2 ovules in 2 rows in each loc. Fruit usually a capsule, rarely drupe or nut. Endosperm. *Chief genera:* Cunonia, Weinmannia. United to Saxifragaceae by Benth.-Hooker; placed in Saxifraginae by Warming.

Cupania Linn. Sapindaceae (1). 32 sp. trop. and subtrop. Am. The wood of some sp. is useful. For *C. sapida* Voigt (= *C. edulis* Schum. et Thonn.) see Blighia.

Cuphea P. Br. Lythraceae. 160 sp. Am. The leaves are decussate and in most sp. there is one flr. at each node, standing *between* the two leaves. This is really the axillary flr. of the leaf below, and its peduncle is 'adnate' to the main stem. Many sp. are covered with exceedingly sticky glandular hairs.

Cupressaceae (Warming) = Araucariaceae § Cupressineae.

Cupressus Tourn. ex Linn. [Synonymy: *C. fastigiata* DC. = *C. sempervirens* L.; *C. pendula* Staunt. = *C. funebris* Endl.; *C. nootkatensis*

Lamb. = *Chamaecyparis nutkatensis* Spach.; *C. thujoides* L. = *Ch. sphaeroidea* Spach.; *C. juniperoides* L. = *Callitris arborea* Schrad. *C. japonica* L. = *Cryptomeria jap.* Don. See Index Kewensis for further synonyms.]

Coniferae (Arauc. 2 c; see C. for genus characters). 12 sp. Medit., As., N.Am. The general habit is xerophytic, the leaves being much reduced and closely appressed to the stems. *C. sempervirens* L. is the cypress of the Medit. region: *C. funebris* Endl. the funereal cypress of China and Thibet, with 'weeping' branches. Several sp. yield useful timber, *e.g.* *C. Lawsoniana* Murr. (Calif., Oregon), *C. Lindleyi* Klotzsch (Mexico), *C. sempervirens*, &c.

Cupuliferae. (Of Benth.-Hooker) = Betulaceae + Fagaceae; (of Warming) = Fagaceae.

Curculigo Gaertn. Amaryllidaceae (III). 12 sp. Indo-mal., N. Austr.

Curcuma Linn. Zingiberaceae. 30 sp. trop. Afr., As., Austr. *C. angustifolia* Roxb. furnishes east indian arrowroot from its tubers. *C. longa* L. yields the yellow dye turmeric, consisting of the dried and ground rhizome. The tubers of *C. Zedoaria* Rosc. yield Zedoary, used in the East as a tonic and perfume.

Curtisia Ait. Cornaceae. 1 sp. S. Afr., *C. faginea* Ait., yielding a hard and useful timber (assegai-wood).

Curvembryae. The 1st series (Benth.-Hooker) of Monochlamydeae. The 7th cohort (Warming) of Choripetalae.

Cuscuta (Tourn.) Linn. Convolvulaceae (II). 90 sp. trop. and temp. Many sp. have largely extended their boundaries through being carried about with their host plants. Leafless and rootless total parasites. The stem twines and is sensitive to contact like a tendril so that it clasps the support tightly; it rarely makes more than three turns about the same branch of the host. At the points in close contact with the host suckers are developed which penetrate the tissues of the host, growing into organic union with them and drawing off all the food materials required by the parasite, which has no green tissue of its own. The seeds of C. germinate later than those of the host plant; a very short anchorage root is formed and the stem nutates in search of a host; as soon as it has clasped one the root dies away. Much damage is often done by these plants: most of the sp. that occur in Brit. (known as dodder, scald, &c.) confine themselves to particular host plants, but others attack a variety of plants. For details see Kerner's *Nat. Hist. of Plants*, vol. I., and papers by Peirce in *Ann. of Bot.* 1893—4; see also p. 176.

Cusparia Humb. Rutaceae (V). 22 sp. S. Am. *C. febrifuga* Humb. (*C. trifoliata* Engl.) yields Angostura or Cusparia bark, sometimes used in place of cinchona bark.

Cuviera DC. Rubiaceae (II. 11). 6 sp. W. trop. Afr. Several are ant-inhabited (p. 114) with hollow swellings of the stem above the nodes (see Schumann in *Ber. d. bot. Ges.* IX. 1891, p. 55).

Cyamopsis DC. Leguminosae (III. 6). 3 sp. trop. Afr., As. *C. psoraloides* DC. is largely cultivated in India as fodder (Guar).

Cyananthus Wall. Campanulaceae (I. 1). 10 sp. Mts. of mid- and E. As. Ovary superior.

Cyanotis D. Don. Commelinaceae. 35 sp. Old World, trop.

Cyathea Sm. Cyatheaceae. About 60 sp. trop. and subtrop. Tree ferns, forming a very characteristic feature in the scenery of various regions. *C. medullaris* Sw. (N. Z.) is well known, also *C. dealbata* Sw. from the same region. Their pulpy pith is eaten by the natives.

Cyatheaceae. Filicineae Leptosporangiatae (Homosporous). 9 gen. with 200 sp. chiefly trop. and subtrop. They are mostly tree ferns with stout erect stems, covered with adventitious roots and a palm-like crown of leaves at the top. These show the circinate vernation, &c., very well. The sori are marginal or on the under side of the leaves, naked or with a cup-shaped indusium; the sporangia are shortly stalked and have a complete excentric annulus. *Chief genera:* Cyathea, Alsophila, Dicksonia, Hemitelia.

Cyathodes Labill. = Styphelia Sm.

Cybianthus Mart. Myrsinaceae (II). 30 sp. trop. Am., Philipp. Is.

Cybistax Mart. Bignoniaceae (II). 3 sp. S. Am. The leaves of *C. Sprucei* K. Sch. are used as a blue dye, by simply boiling them with the cloth.

Cycadaceae. Gymnospermae. 9 genera with about 75 sp. The survivors of a group of plants which in past ages figured largely in the composition of the flora of the earth. They reached their maximum about the end of the Triassic and beginning of the Jurassic period. The C. represent the lowest type of living Phanerogams and remind us, in their appearance and habit, of the tree-ferns. The stem is usually short and stout, only growing to any noteworthy height in Cycas itself, and is often tuberously swollen. It has a long primary tap root. In some sp. a sort of felt-work of roots is formed at the base of the stem, and a number of short lateral branches of these stand erect and may emerge from the soil (see *Nat. Pfl.*). At the end of the stem there is usually a crown of leaves, and its lower portion is covered with scales. There are, in all C. except a few sp. of Macrozamia, two sorts of leaves, foliage- and scale-leaves. They are borne spirally upon the stem, and alternately with one another, as a rule several circles of scales before each circle of foliage leaves, which they protect in the bud. The scales are really leaf bases whose blades abort. The foliage leaves are very characteristic. They possess usually a thickened, woody, more or less sheathing base, which often persists after the fall of the rest of the leaf. There is a stout rachis or petiole, frequently thorny at the base, the thorns being 'metamorphosed' leaflets. Upon its upper side are two grooves, from which spring the leaflets, which may or may not be opposite to one another; there is usually no terminal leaflet. The leaflets may be entire or toothed and are usually very rigid and leathery. The nervature is important. Three types occur:

(1) midrib, no lateral nerves: Cycas.
(2) midrib and lateral nerves: Stangeria.
(3) numerous parallel or wavy, simple or forked nerves running longitudinally: the other genera.

The flrs. are diœcious and usually take the form of *cones*; these are terminal, and so the stem becomes a sympodium, except in Cycas ♀, where the stem 'grows through' the flr. (the only case of this phenomenon in Phanerogams). The size of the cones varies considerably. Each consists essentially of a central axis bearing a number of fertile leaves or sporophylls; occasionally the lowest leaves are sterile as in Coniferae. In the ♂ cone, the leaves (scales) are generally of a sort of nail shape (cf. Equisetum), and bear *sori* upon the lower side. Each sorus consists of 2—6 sporangia (pollen-sacs), arranged with the lines of dehiscence radiating from the common centre. In the ♀ cone the scale (cpl.) is of somewhat similar shape but bears as a rule only two sporangia (ovules), whose apices are directed towards the axis of the cone. Cycas (q.v.) has no proper cone, but the stem bears a whorl of cpls. in place of ordinary leaves. The ovule is of considerable size, orthotropous with one integument. [For details of internal structure of ovule, fertilisation, &c., see text-books, and art. *Gymnospermae*.] The pollen is carried by the wind to the micropyle, where it germinates.

The ovule grows into a large seed; the testa is two-layered, the inner layer woody, the outer fleshy. There is also an endopleura on the seed. The nucellus is reduced to a thin cap on the top of the seed, the bulk of which consists of endosperm, with a straight embryo in the centre. There are 2 cotyledons, usually united at the tips.

The C. are exclusively trop. and subtrop. Of the genera, 4, 7, 8, 9 (see below) are from Am., 3 and 6 Austr., 2 and 5 Afr., whilst Cycas is found in E. Ind., Austr., and the islands of Ind. and Pacif. Oceans.

Classification and Genera.

I. *Cycadeae* (cpls. with 8—4, rarely 2 ovules; stem growing through the ♀ flr.; leaflet with midrib only): 1. Cycas.

II. *Zamieae* (ovules 2; stem not growing through): 2. Stangeria (pinna pinnately nerved); 3. Bowenia (leaf bipinnate); 4. Dioon; 5. Encephalartos; 6. Macrozamia; 7. Zamia; 8. Ceratozamia; 9. Microcycas.

[The above account of the order is abridged from that of Eichler in *Nat. Pfl.*]

Cycas Linn. Cycadaceae. 16 sp. trop. E. Ind., Austr., Polynes. For genus characters &c., see order. The female plant does not bear a cone, but bears a whorl of cpls. of a woolly brown appearance; in notches upon the margins of these are the naked ovules, usually 4—8 in number. The pith of *C. circinalis* L. (trop. As.) and *C. revoluta* Thunb. (Japan) yields a kind of sago.

Cyclamen (Tourn.) Linn. Primulaceae (IV). 10 sp. Eur. (mostly alpine), Medit. *C. europaeum* L. in Brit. (sow-bread). There is a stout corm (p. 152) due to the thickening of the hypocotyl. The perianth-lobes are bent back and the flr. is pendulous, with a loose-pollen mechanism (p. 98) as in Erica. After fertilisation the stalk usually coils up spirally drawing the ripening fruit down to the soil (cf. Vallisneria); in *C. persicum* Sibth. et Sm. it bends over and forces the fruit into the ground (cf. Arachis).

Cyclanthaceae. Monocotyledons (Synanthae). 6 gen. with 45 sp. trop. Am.; they help to characterise the flora of this region (p. 195). Climbers, epiphytes, rhizome-herbs, or small shrubs, of palm-like habit, with curious spadix infls. on which the ♂ and ♀ flrs. alternate in various ways (see Carludovica and Cyclanthus). The order is nearly related to the Palmae, Pandanaceae and Araceae; it is placed in Spadiciflorae by Warming, in Nudiflorae by Benth.-Hooker. *Chief genera:* Carludovica, Cyclanthus.

Cyclanthera Schrad. Cucurbitaceae (V). Over 30 sp. trop. Am. The sta. are combined into a column as in section IV, but here the anther-loculi are fused into 2 ring-shaped loculi running completely round the top of the column. *C. explodens* Naud. has an explosive fruit (cf. Ecballium); the pericarp is extremely turgid on its inner surface, and the fruit dehisces into valves, each of which rolls back on itself with a violent jerk.

Cyclanthus Poit. Cyclanthaceae. A unique genus. 4 sp. trop. Am. The rhizome bears large leaves, forked into two at the top. Infl. terminal on a long stalk (figs. in *Nat. Pfl.*), as a large cylindrical spadix with big bracts at the base. The spadix resembles a number of discs piled upon one another, with their edges sharpened to a thin rim. In some sp. two parallel spirals compose the spadix, each with a sharpened edge. In the former case every other disc bears ♂ flrs., in the latter one of the spirals, the other being ♀. The ♂ flrs. occupy a groove at the edge of the rim; each has 6 sta. and no perianth. The ♀ flrs. are embedded in the disc and their ovaries are united into a long continuous chamber running all round the disc and containing numerous placentae. The perianths also are united all round the disc; on their inner sides they bear staminodes. The fruit is multiple, consisting of a number of seeds embedded in a general fleshy mass formed of the ovaries and spadix. Cf. Carludovica.

Cycnoches Lindl. Orchidaceae (17) 8 sp. trop. Am. The flr. is like that of Catasetum in mechanism and polymorphism.

Cydonia Tourn. ex Mill. = Pyrus Tourn. *C. vulgaris* Pers. = *P. Cydonia* L.; *C. japonica* Pers. = *P. japonica* Thunb.

Cymbalaria Medic. = Linaria Mill.

Cymbidium Sw. Orchidaceae (24). 30 sp. E. Ind., China, Austr., Afr.

Cynanchum Linn. (incl. *Vincetoxicum* Rupp.). Asclepiadaceae (II. 2). 100 sp. trop. and temp. Many are twiners, and xerophytes with fleshy stems and reduced leaves. The flrs. are fertilised by carrion-flies which get the pollinia attached to their proboscides.

Cynara Vaill. ex Linn. Compositae (XI). 11 sp. Medit. *C. Scolymus* L. is the true artichoke (see Helianthus). The young flr.-heads enclosed in the involucral bracts form a valuable pot-herb. *C. Cardunculus* L. is the cardoon, whose leaves are blanched and eaten like those of celery. This sp. has spread over great areas on the Pampas, where it was introduced (p. 24).

Cynocrambaceae (*Thelygonaceae*). Dicotyledons (Archichl. Centrospermae). An order consisting only of the one genus Cynocrambe (Thelygonum), which is of so anomalous a character that it has been placed near to Urticaceae (to which it is united by Benth.-Hooker), Phytolaccaceae (to which it is united by Warming), Chenopodiaceae, Begoniaceae, Santalaceae, Monimiaceae, &c. (see *Nat. Pfl.*). For details see Thelygonum.

Cynocrambe Tourn. ex Adans = Thelygonum Linn.

Cynodon Rich. Gramineae (XI). 3 sp. Austr., the other, *C. Dactylon* Pers., the dog's-tooth or Bermuda grass, cosmop. (incl. Brit.). It grows with creeping stems on sandy soil and is used for binding dunes (p. 186); it forms a useful pasture on such soils. Spikes digitate, spikelets 1-flowered.

Cynoglossum (Tourn.) Linn. Boraginaceae (IV. 1). 50 sp. temp. and subtrop. *C. officinale* L. (hound's tongue) and another in Brit. Formerly officinal. The fruit is hooked.

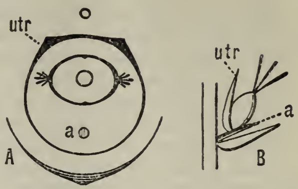
Cynometra Linn. Leguminosae (II. 2). 27 sp. trop. *C. cauliflora* L. is a good example of stem-fruiting (p. 156).

Cynomorium Mich. ex Linn. Balanophoraceae. 1 sp. Medit., *C. coccineum* L.

Cynosurus Linn. Gramineae (X). 5 sp. Old World temp., 2 in Brit. (dog's-tail grass), one of which, *C. cristatus* L., is a valuable pasture and fodder grass.

Cypella Herb. Iridaceae (II. 1). 5 sp. S. Am. One sp. increases its conspicuousness by unfolding its flrs. in great numbers at definite times (F. Müller).

Cyperaceae. Monocotyledons (Glumiflorae). 65 genera with over 2500 sp., cosmop., chiefly marsh-plants. Grass-like plants, mostly perennials with creeping sympodial rhizomes. The new shoot of each year is adnate (p. 30), for an internode or more, to the parent shoot, so that the branching seems at first sight extra-axillary. The aerial shoot is usually grass-like, but the stem is generally solid and angular with 3 ranks of leaves. The leaf is sheathing at the base, but the sheath is entire, not split as in a grass. The unit of infl. is again a spikelet; the total infl. may be a spike or panicle as in grasses. In many sedges the spikelet is cymose—a sympodium—and should perhaps be termed a pseudo-spikelet. The flr. is borne in the axil of a glume and may be ☿ or unisexual; it is usually naked but may have a perianth of 6 (or ∞) small scales or hairs. Sta. 3, cpls. (3) or (2) forming a 1-loc. ovary, with long feathery (anemophilous) stigmas. Ovule 1, basal, anatropous. In Carex &c. the ♀ flr. is borne in the axil of a second glume (the *utricle*) which closely enwraps it (in the figure it is shown diagrammatically). The flrs. are wind-pollinated. Fruit an achene, the testa not adhering to the pericarp. The sedges are of little economic value; see Cyperus.



Diagrams of Carex (after Eichler). A, diagram of a 2-carpelled ♀ flr.; B, side view of ♀ flr. a.=axis of spikelet; utr. =utricle.

Classification and chief genera (after Pax):

I. *SCIRPOIDEAE* (spikelets with no terminal flr., always 2-sexual; flr. almost always ☿): Cyperus, Eriophorum, Scirpus, Eleocharis, Fimbristylis.

II. *CARICOIDEAE* (spikelets 1-sexual or andro-monœcious; flr. rarely ☿, usually monœcious; ♂ and ♀ flrs. on axes of different orders): Schoenus, Rhynchospora, Carex.

[C. are placed in Glumaceae by Benth.-Hooker, Glumiflorae by Eichler.]

Cyperus Linn. (incl. *Mariscus* Gaertn.). Cyperaceae (1). 400 sp. trop. and warm temp. (2 in S. England, rare). Herbs with sympodial rhizome and leafless or leafy shoots above ground. Infl. umbel- or head-like. The most interesting sp. is *C. Papyrus* L., the paper-reed, a river-side plant with shoots 3—12 feet high. From the stems was made the ancient writing paper, papyrus. The stem was split into thin strips and these were pressed together while still wet. The rhizome is edible, and also the root-tubers of several sp.

Cyphia Berg. Campanulaceae (II). 20 sp. Afr. [Cyphiaceae, Warming.]

Cyphokentia Brongn. Palmae (IV. 6). 10 sp. New Caled.

Cyphomandra Mart. ex Sendtn. Solanaceae (II. 5). 30 sp. S. Am.

Cypripedium Linn. Orchidaceae (2). 20 sp. N. temp. and subtrop. (*C. Calceolus* L. in Brit.). Lady's-slipper orchids. Terrestrial acranthous plants. The lateral sepals are completely united. The labellum is slipper-like with inturned edge; at its base is the column, partly enclosed in it. The large staminode (see order) is visible outside the labellum; under it are the two anthers, and lower down the flat stigma. The pollen is glutinous and not united into pollinia. Insects (mostly bees) visiting the flr. get inside the labellum and cannot get out by the way they entered, so have to pass out by the openings at the base, in doing which they brush first against the stigma and then against the anthers.

Cyrilla Garden. Cyrillaceae. 1 sp. Carolina to Brazil, a marsh plant with evergreen leaves, and flrs. in racemes below them.

Cyrillaceae. Dicotyledons (Archichl. Sapindales). 3 gen. with 5 sp. Am. Evergreen shrubs with alt., exstip. leaves and racemes of ☿, regular flrs. K 5, imbricate, persistent; C 5 or (5), imbricate; A 5 + 5 or 5, with introrse anthers; $\underline{G}$ (5—2), multi-loc. with 1 (rarely 2—4) pendulous anatropous ovule in each loc.; raphe dorsal, micropyle facing upwards and inwards. Embryo straight, in endosperm. *Genera:* Cliftonia, Costaea, Cyrilla. Placed in Olacales by Benth.-Hooker.

Cyrtandra Forst. Gesneraceae (1). 180 sp. Is. of Ind. and Pacif. Oceans, As.

Cyrtanthus Ait. Amaryllidaceae (1). 16 sp. S. Afr.

Cyrtopodium R. Br. Orchidaceae (16). 3 sp. trop. Am.

Cyrtostylis R. Br. Orchidaceae (4). 2 sp. Austr., N.Z.

Cystopteris Bernh. Polypodiaceae. 5 sp. alpine and arctic. *C. fragilis* Bernh. (bladder-fern) is common in Brit. and *C. montana* Link occurs on a few Scottish Mts. In *C. bulbifera* Bernh. adventitious buds on the petioles give rise to new plants.

Cytinaceae (Benth.-Hooker) = Rafflesiaceae + Hydnoraceae. Placed in Multiovulatae Terrestres.

Cytinus Linn. Rafflesiaceae. 2 sp. Afr.

Cytisus Linn. (incl. *Sarothamnus* Wimm., excl. *Laburnum* L.). Leguminosae (III. 3). 40 sp. Eur., Medit. *C.* (*S.*) *scoparius* Link, the broom, in Brit. The leaves in this sp. are reduced to scales and assimilation is chiefly performed by the stems. The flr. has an explosive mechanism; in general principle this is like that of Genista (q.v.), but it differs in detail. The style is very long and there are two lengths of sta., so that pollen is shed near the tip of the keel and also about half way along its upper side. The stigma is in the extreme tip of the keel. When an insect alights on the flr. (there is no honey), the keel begins to split from the base towards the tip, and presently the pollen of the short sta. is shot out upon the lower surface of the visitor; immediately afterwards, the split having reached the tip, the other pollen and the style spring violently out and strike the insect on the back. As the stigma touches first there is thus a chance of a cross, if the insect bear any pollen. After the visitor's departure the style bends right round and the stigma comes to occupy a position just above the short sta., so that another chance of cross-fertilisation is afforded if other insects visit the flr. (in most exploding flrs. there is only the one chance). Other sp. of C. have simple mechanisms like Trifolium. The fruit explodes by a twisting of the valves.

C. Adami Poit. is a curious graft-hybrid between *C. purpureus* Scop. and *Laburnum vulgare*. The latter was used as the stock; the shoots above the graft exhibit hybrid characters (see Darwin, *Variation under Domest.* ch. XI).

Daboecia D. Don (or *Dabeocia*). Ericaceae (I. 3). 1 sp. *D. polifolia* D. Don (St Dabeoc's heath), in Atl. Eur. (incl. Ireland).

Dacrydium Soland. Coniferae (Taxaceae, 3; see C. for genus characters). 12 sp. Malaya, N. Z., Tasm. Most are diœcious. Fruit scales 1 or 2 or more. Seed arillate.

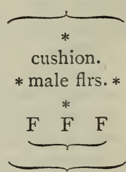
Dactylis Linn. Gramineae (X). 1 sp. Eur. (incl. Brit.), Medit., As., *D. glomerata* L., the cock's-foot, a valuable pasture grass.

Dahlia Cav. Compositae (V). 9 sp. Mexico. Perennial herbs with tuberous roots. Many varieties of *D. variabilis* Desf. and other sp. are in cultivation; the double forms have the disc florets ligulate as well as the ray (cf. Chrysanthemum).

Dalbergia Linn. f. Leguminosae (III. 8). 80 sp. trop. Several are lianes. *D. variabilis* Vog. is a shrub with pendulous twigs when growing in the open, but in the forest becomes a liane climbing by aid of short lateral shoots which are sensitive to contact. Many sp. yield valuable wood, *e.g.* the Indian sp. *D. latifolia* Roxb. (blackwood or East Indian rosewood), and *D. Sissoo* Roxb. (Sissoo).

Dalea Linn. Leguminosae (III. 6). 100 sp. Am.

Dalechampia Plum. ex Linn. Euphorbiaceae (A. II. 2). 60 sp. trop. *D. Roezliana* Müll.-Arg. is often grown as a stove plant; it has a very complex infl., whose construction is roughly indicated in the diagram. The whole is enclosed in two large outer bracts (the big brackets), which are coloured pink or white. Above these on the axis is a smaller bract (the little bracket), in whose axil is a 3-flowered cyme of ♀ flrs. (F). Above this is the ♂ part of the infl., starting with 4 bracts (in the positions represented by the asterisks). Above these, anteriorly are 9—14 ♂ flrs. and posteriorly a curious yellow cushion, consisting of rudimentary ♂ flrs. In a sp. described by F. Müller the cushion secretes resin, which is used by bees for nest making, and attracts them to the flr.



Dalibarda Linn. = Rubus Tourn. *D. repens* L. = *R. Dalibarda* L.

Damasonium Mill. Alismaceae. 3 sp. Eur., Austr.

Dammara (Rumph) Lam. = Agathis Salisb.

Dampiera R. Br. Goodeniaceae. 34 sp. Austr.

Danaea Sm. Marattiaceae (III). 11 sp. Am. The stem branches, a rare character in M. The synangia are very long, sometimes reaching from midrib to margin of the leaf. They open by a terminal pore.

Danthonia DC. Gramineae (IX). 100 sp. trop. and temp., esp. S. Afr.

Daphnales (Benth.-Hooker). The 5th series of Monochlamydeae.

Daphne Tourn. ex Linn. Thymelaeaceae. 40 sp. Eur., temp. and subtrop. As.; *D. Mezereum* L., the Mezereon and *D. Laureola* L., the spurge-laurel, in Brit. Honey is secreted by the base of the ovary, and the depth of the tube preserves it for long-tongued insects. Several sp. are cultivated.

Daphniphyllum Blume. Euphorbiaceae (A. I. 3). 12 sp. trop. Afr., Indo-mal., China, &c.

Daphnopsis Mart. et Zucc. Thymelaeaceae. 25 sp. S. Am., Mexico, W. Ind.

Darlingtonia Torr. Sarraceniaceae. 1 sp. Calif., a pitcher plant like Sarracenia, but with the top of the tube bent over and with a fish-tail-shaped flap in front of the opening.

Darwinia Rudge. Myrtaceae (3). 25 sp. Austr. Heath-like shrubs.

Dasylirion Zucc. Liliaceae (VI). 10 sp. Texas, Mexico. Xerophytes of Aloe-like habit with woody, often tuberous, stems, and hard leaves. Flrs. diœcious, in gigantic infl.

Datisca Linn. Datiscaceae. 2 sp. N. Am., W. As.

Datiscaceae. Dicotyledons (Archichl. Parietales). 3 gen. with 4 sp., trop. and temp. Trees or herbs with exstip. leaves and racemes or spikes of regular, usually diœcious, sometimes apetalous flrs. In the ♂ flr.: K 4—9, free or united; C 4—9 or 0; A 4—9 or ∞. In the ♀: K 3—8, united to one another and to the ovary; C 0; $\bar{G}$ (3—8), with free styles. Ovary 1-loc. with parietal placentae and ∞ anatropous ovules. Capsule. No endosperm. *Genera:* Datisca, Tetrameles, Octomeles. The affinities of D. are doubtful (see *Nat. Pfl.*); they are probably most nearly allied to Begoniaceae. Benth.-Hooker place them in Passiflorales, Warming in Passiflorinae.

Datura Linn. Solanaceae (III. 6). 15 sp. trop. and warm temp. *D. Stramonium* L., the thorn-apple, is sometimes found as an escape in Brit. It has a 4-loc. ovary (see order) giving a 4-valved capsule covered with spines. The leaves and seeds are used in medicine.

Daucus (Tourn.) Linn. Umbelliferae (8). 50 sp. Eur., As., Afr., Am. *D. Carota* L. the carrot, in Brit. The cultivated form has much more fleshy roots than the wild. In the centre of the umbel is usually a red terminal flr. After fertilisation the peduncles all bend inwards until the fruits are ripe and then spread out again to allow the burred mericarps to adhere to animals.

Davallia Sm. Polypodiaceae. 80 sp. mostly trop. Sori marginal.

Daviesia Sm. Leguminosae (III. 2). 55 sp. Austr.

Davilla Vand. Dilleniaceae. 25 sp. trop. Am. The two inner sepals are larger than the rest and grow straight upwards. After fertilisation they grow woody or leathery and enclose the fruit.

Debregeasia Gaud. Urticaceae (3). 5 sp. Abyss., S. and E. As. *D. edulis* Wedd. is the Janatsi of Japan, yielding edible fruit and useful fibre (cf. Boehmeria).

Decaisnea Hook. f. et Thoms. Lardizabalaceae. 1 sp. Himal., *D.* insignis H. f. et T., with edible fruit (see Hooker's *Himal. Journal*, chap. XXV.).

Deguelia Aubl. = Derris Lour.

Deherainea Dcne. Myrsinaceae (I). 1 sp. Mexico, *D. smaragdina* Dcne, noteworthy for its large green flrs., which owe their colour to chlorophyll. They have an unpleasant smell and are very probably fertilised by large flies. The young flr. shows the extrorse anthers quite hiding the stigma, but later on the sta. move outwards and rest on the corolla.

Delphinium Tourn. ex Linn. Ranunculaceae (2). 120 sp. N. temp. *D. Ajacis* L., the larkspur is found in Brit. and several sp. are cultivated for their flrs. Flrs. zygomorphic in racemes; the posterior sepal is drawn out into a spur containing the spurs of the two posterior petals, in which the honey is secreted. [Cf. this mode of protection with that in Aconitum, which is far more frequently robbed by humble-bees.] The flr. is protandrous with movement of the sta., and is fertilised by humble-bees. The open flr. projects horizontally, but subsequently the stalk bends upwards and the follicles stand erect so that the seeds can only escape if they are shaken *e.g.* by strong wind.

Dendrobium Sw. Orchidaceae (21). 300 sp. trop. As., Japan, Austr., Polynes. Epiphytes. Many are favourites in cultivation. For floral mechanism see Darwin's *Orchids*, p. 138.

Dendrocalamus Nees. Gramineae (XIII). 9 sp. Indo-mal., China. Large bamboos (see Bambusa).

Dendrochilum Blume. Orchidaceae (22). 3 sp. Indo-mal.

Dentaria (Tourn.) Linn. = Cardamine Linn.

Derris Lour. (*Deguelia* Aubl.). Leguminosae (III. 8). 40 sp. trop.

Deschampsia Beauv. Gramineae (IX). 20 sp. temp. and frigid. *D. caespitosa* Beauv. (*Aira*) and *D. flexuosa* Trin. are common in Brit. (hair grass). They are of tufted growth and are rough fodder grasses.

Desfontainia Ruiz et Pav. Loganiaceae. 1 sp. Andes, *D. spinosa* R. et P., a pretty holly-like shrub. Its position in the order is doubtful. The ovary has 5 loculi.

Desmanthus Willd. Leguminosae (I. 3). 9 sp. sub-trop. N. Am., 1 Madag.

Desmodium Desv. Leguminosae (III. 7). 150 sp. trop. and sub-trop. The most interesting sp. is *D. gyrans* DC. the telegraph plant (the name dates from the days of semaphore telegraphy). During the day, provided the temperature be not below 72°F. the two small lateral leaflets of each leaf move steadily round in elliptical orbits. The meaning of this phenomenon is unknown. See Darwin's *Movements of Plants*. At night the leaves sleep, drooping downwards. Several sp. are useful as fodder plants, and are cultivated like clover.

Desmoncus Mart. Palmae (IV. 7). 20 sp. trop. Am. Climbing palms with reedy stems, and hooks like those of Calamus.

Deutzia Thunb. Saxifragaceae (III). 10 sp. N. temp. Ovary inferior 3—4-loc. The fruit splits septicidally into its cpls. which open each at its apex. The seed is provided with a winged testa, very light.

Deyeuxia Clar. = Calamagrostis Adans.

Dialium Linn. Leguminosae (II. 5). 9 sp. trop. Petals 2, 1, or 0; sta. 2, or rarely 3. *D. guineense* Willd. (trop. Afr.) is the velvet tamarind; the pod is covered with a velvety down and contains an edible pulp. Its wood is useful and resists the action of salt water well. *D. indum* L. (Java) the tamarind plum, and others have also edible fruit.

Dianella Lam. Liliaceae (III). 11 sp. trop. As., Austr.

Dianthera Gronov. Acanthaceae (IV. B). 70 sp. trop. Am. Included in Justicia in *Nat. Pfl.*

Dianthus Linn. Caryophyllaceae (I. 2). About 230 sp. Eur., As., Afr., N. Am., but esp. Medit., mostly in dry sunny situations (4 in Brit.—the Pinks). The genus is readily known by the bracts under the calyx. The flrs. are very protandrous, and adapted to butterflies. *D. barbatus* L. is the Sweet William, and *D. Caryophyllus* L. is the parent form of the cultivated Carnation (p. 101).

Diapensia Linn. Diapensiaceae. 2 sp., one Himal., the other, *D. lapponica* L., circumpolar boreal. It has a tufted habit, like so many alpine and arctic plants. The flrs. are protogynous.

Diapensiaceae. Dicotyledons (Sympet. Ericales). 6 gen. with 9 sp., N. Hemisph., chiefly alpine and arctic. They are evergreen under-shrubs, with rosettes of leaves; the flrs. solitary or in racemes, with two bracteoles, ☿, actinomorphic, without a disc. K (5) or 5, C (5) nearly polypetalous, A 5, epipetalous, opposite sepals, with frequently 5 staminodes opp. petals; anthers transverse, each lobe opening by longitudinal slit; pollen simple. $\underline{G}$ (3) with axile placentae bearing ∞ anatropous or amphitropous ovules; style simple with 3-lobed capitate stigma. Fruit a loculicidal capsule. Embryo cylindrical, endosperm fleshy. *Chief genera:* Diapensia, Shortia, Galax. Placed in Ericales by Benth.-Hooker, in Bicornes by Warming.

Diascia Link et Otto. Scrophulariaceae (II. 3). 22 sp. S. Afr.

Dicentra Bernh. Papaveraceae (III). 15 sp. As., N. Am. *D. Cucullaria* Bernh. (Dutchman's breeches) and other sp. are favourites in cultivation. The rhizome of many sp. (§ *Cucullaria*) resembles a succession of bulbs, on account of the fleshiness of the scale leaves and of the sheathing bases of the foliage leaves. The materials formed in the leaf during the growing season are stored up in the fleshy base, which survives the winter, while the rest of the leaf dies. The flrs. are in racemes and pendulous. Each of the outer petals is developed into a large pouch at its base, and the sta. (here branched from the very base) follow the outer curve of the pouch. The inner petals are spoon-shaped and cohere at the tip, forming a hood which completely covers the anthers and stigma. The pendulous position and complex structure of the flr. render it specially suited to bees, which hang on to it and probe for honey first one side, then the other (the honey is in the pouches of the petals). In so doing they push aside the hood and touch the stigma, on which there is usually pollen from its own sta.

Dichaea Lindl. Orchidaceae (30). 5 sp. trop. Am. Monopodial creeping epiphytes with sheathing leaves.

Dichapetalaceae = Chailletiaceae.

Dichapetalum Thou. = Chailletia DC.

Dichilus DC. Leguminosae (III. 3). 3 sp. S. Afr.

Dichondra Forst. Convolvulaceae (I. 1). 5 sp. trop., some amphicarpic.

Dichopogon Kunth. Liliaceae (III). 2 sp. Austr.

Dichopsis Thw. = Palaquium Blanco.

Dichorisandra Mikan. Commelinaceae. 30 sp. trop. Am. Infl. racemose (*cf.* order); its branches often pierce the leaf-sheath.

Dichroa Lour. Saxifragaceae (III). 1 sp. Himal. and China to Java.

Dichromena Michx. Cyperaceae (I). 8 sp. Am.

Dichrostachys Wight et Arn. Leguminosae (I. 4). 7 sp. trop. As., Afr., Austr. Stipules often thorny. Upper flrs. of infl. ☿, yellow, lower neuter and white, rose, or purple.

Dicksonia L'Hérit. (incl. *Cibotium* Kaulf.) Cyatheaceae. 30 sp. trop. and S. Hemisph. Most are tree ferns, *e.g. D. antarctica* Labill. (Austr., N. Z.) Sori marginal. The famous Tartarian lamb of early travellers was the rhizome of a sp. of D. See *Treas. of Bot.* art. Cibotium.

Dicliptera Juss. Acanthaceae (IV. B). 60 sp. trop.

Diclytra Borckh. = Dicentra Bernh.

Dicoma Cass. Compositae (XII). 24 sp. Afr., Madag., trop. As.

Dicoryphe Thou. Hamamelidaceae. 13 sp. Madag., Comoro Is.

Dicotyledones. One of the two great divisions of Angiospermae (*q.v.*).

Dicræa (Du Pet. Th.) Tul. Podostemaceae. 7 sp. Madag., Ceylon, India. Thallus (root) drifting from attached base, exogenously branched, with marginal secondary shoots. Fruit isolobous.

Dicranostyles Benth. Convolvulaceae (I. 2). 2 sp. trop. S. Am.

Dictamnus Linn. Rutaceae (II). 1 sp. Eur. As., *D. albus* L. (*D. Fraxinella* Pers.), the dittany or candle-plant. The ethereal oil secreted by the plant is very volatile and inflammable, so that on hot calm days the air round it may sometimes be ignited by a flame and the plant itself burnt. The flr. is zygomorphic; the unripe sta. are curved downwards, and bend upwards to dehisce. The fruit opens elastically.

Dictyoloma DC. Rutaceae (VI). 2 sp. Brazil.

Dictyosperma Wendl. et Drude. Palmae (IV. 6). 3 sp. Mascarenes.

Didierea Baill. Sapindaceae (?) 2 sp. Madag. Anomalous plants with the habit of cactus-like Euphoribas, and of doubtful affinity. See *Nat. Pfl.* III. 5, p. 461, *Kew Bull.* 1898, p. 97.

Didymocarpus Wall. (*Rottlera* Vahl). Gesneriaceae (I). 80 sp. Indo-mal., China, Madag., Austr.

Didymochlaena Desv. Polypodiaceae. 2 sp. trop. Am., Malaya.

Didymosperma H. Wendl. et Drude. Palmae (IV. 6). 8 sp. Indo-mal.

Dieffenbachia Schott. Araceae (V). 12 sp. trop. Am. Flrs. monoecious, naked; the ♂ is a synandrium of 4 or 5 sta. *D. Seguine* Schott is the 'dumb cane' of the W. Ind.; its juice is very acrid and renders speechless a person who chews a piece of the stem. It was formerly used in torturing slaves.

Dielytra Cham. et Schlecht. = Dicentra Bernh.

Diervilla Tourn. ex Linn. (*Weigelia* Thunb.). Caprifoliaceae (4). 8 sp. E. As., N. Am. *D. florida* Sieb. et Zucc., and others, are favourite garden shrubs. The flr. is adapted to bees and changes colour after fertilisation (? only the effect of age); see Ribes, Fumaria, &c.

Dietes Salisb. = Moraea Linn.

Digitalis (Tourn.) Linn. Scrophulariaceae (III. 10). 22 sp. Eur., W. As., Canary Is. *D. purpurea* L., the foxglove, is common in Brit. The flrs. are in racemes, which become one-sided by twisting of the peduncles. They are adapted to fertilisation by bees. The leaves are officinal, containing the poisonous alkaloid digitalin.

Digitaria Heist. ex Adans. = Panicum Linn.

Digraphis Trin. = Phalaris Linn.

Dillenia Linn. (excl. Wormia Rottb.) Dilleniaceae. 25 sp. trop. As. to Austr.

Dilleniaceae. Dicotyledons (Archichl. Parietales). 12 gen. with 180 sp., trop. They are especially well represented in the Australian 'scrub' vegetation. Most are trees and shrubs (many lianes) with alt. usually leathery leaves and cymose infl. Flr. ☿. K 5, or 3, 4 or even ∞, spiral, persistent after flowering; C usually 5; A ∞, hypogynous, free or united at base. Cpls. ∞—1, free or more or less united; styles usually free. Ovules ∞—1, erect, anatropous, with ventral raphe. Placentae usually inconspicuous, unthickened. Seed always with a funicular aril united to the testa. Endosperm copious; embryo small, straight. *Chief genera:* Hibbertia, Dillenia. Placed in Ranales, with which they have much in common, by Benth.-Hooker, in Cistiflorae by Warming. For details of the interesting floral morphology see *Nat. Pfl.*

Dimorphandra Schott. Leguminosae (II. 1). 10 sp. trop. Am.

Dimorphanthus Miq. = Aralia Tourn.

Dimorphotheca Vaill. ex Linn. Compositae (X). 20 sp. S. Afr. There are two kinds of fruit on the head (cf. Calendula).

Dionaea Ellis. Droseraceae. 1 sp. Carolina. *D. muscipula* Ellis, well known under the name of Venus' fly-trap. It grows in damp mossy places on the 'pine-barrens.' There is a short rhizome bearing a rosette of leaves, which lie close to the soil. Each has a lower and an upper blade; the former may be regarded as a winged petiole, the latter has a quadrangular shape and the margins project as long teeth close together like those of a comb. The two halves of this part of the leaf are bent upwards so as to present a flat V-form in section. The edge of each half is green, the inner part of the surface is covered with reddish dots, which under the microscope are seen to be digestive glands; unless stimulated, no secretion is carried on by them. On each half of the leaf are three long hairs—the trigger-hairs—jointed at the base so that they fold downwards when the leaf closes. The slightest touch given to one of these hairs, or a more vigorous stimulus applied to the surface of the leaf, causes an immediate closing of the two halves of the blade. The teeth cross one another, and if an insect cause the movement, it is thus captured. The closing of the leaf still continues till the two halves are tightly squeezed together. Then the digestive glands commence to secrete a ferment which acts upon the proteids of the prey and renders them soluble, when they are absorbed by the leaf (cf. Drosera and see p. 178). When the process is complete the leaf opens out again. [For further details, see Macfarlane in *Contrib. from Bot. Lab. Pennsylv. Univ.* I. 1892.]

Dionysia Fenzl. Primulaceae (I). 12 sp. alpine Persia, Afghanistan.

Dioon Lindl. Cycadaceae. 2 sp. Mexico. The seeds are ground into meal, which contains much starch.

Dioscorea Plum. ex Linn. Dioscoreaceae. 150 sp. trop. and sub-trop. They have twining annual stems arising from tubers which in different sp. are of different morphological nature. In *D. Batatas* Dcne., &c. the tuber arises by a lateral hypertrophy of the hypocotyl, and is variously regarded as a rhizome or a root; in *D. sinuata* Vel., &c. it arises by lateral hypertrophy of the internodes above the cotyledon; in *D. pentaphylla* L., &c. it arises from the internode just above the cotyledon together with the hypocotyl, whilst in *D. villosa* L., *D. quinqueloba* Thunb., &c., there is a fleshy rhizome. The tubers are known as yams; they contain much starch and are largely cultivated for food in tropical countries. They are propagated by cutting out the 'eyes' as in potatoes. Small axillary tubers often form on the main stem and may also be used for propagation.

Dioscoreaceae. Monocotyledons (Liliiflorae). 9 gen. with 170 sp. trop. and warm temp. Climbing herbs or shrubs with tubers or rhizomes at the base (the morphology of these is very varied; see chief genera). Leaves alt., net-veined, often arrow-shaped. Infl. racemose. Flrs. regular, usually diœcious, inconspicuous. P (6), tubular at base; A 6, or 3 and 3 staminodes; $\overline{G}$ (3) usually 3-loc. with axile, rarely 1-loc. with parietal, placentae. Ovules usually 2 in each loc., anatropous, one above the other. Capsule or berry. Embryo in horny endosperm. The tubers of Dioscorea are valuable as food stuffs; those of Testudinaria are also used. *Chief genera:* Dioscorea, Testudinaria, Tamus. Placed in Epigynae by Benth.-Hooker, in Liliiflorae by Warming. [See Quéva, *Réch. sur l'anat. de l'app. végét. d. Taccacées et d. Dioscorées*, Lille. 1894.]

Diosma Linn. Rutaceae (IV). 11 sp. S. Afr. Heath-like xerophytes.

Diospyrinae (Warming). The 2nd cohort of Sympetalae (p. 137).

Diospyros Linn. Ebenaceae. 180 sp. trop. Many sp. yield the valuable wood ebony. The sapwood is white and soft, the heart-wood hard and black. *D. reticulata* Willd. (Mauritius) and *D. Ebenum* Koen. (Ceylon) yield the finest ebony. *D. Embryopteris* Pers. is the gaub tree of India; its fruit contains a sticky pulp, used for caulking seams in boats. *D. Kaki* L. f. is the Chinese date plum, or persimmon, whose fruit is used as a sweetmeat when dried, *D. Lotus* L. (temp. As.) the common date-plum. *D. virginiana* L. (U.S.) is the N. Am. ebony or persimmon, cultivated for both wood and fruit.

Diotis Desf. Compositae (VII). 1 sp. *D. candidissima* Desf. (*D. maritima* Sm.), the cotton-weed, on the coasts of Brit., W. Eur., and the Medit. A hairy perennial (p. 186).

Dipcadi Medic. Liliaceae (V). 12 sp. Afr., Medit., trop. As.

Diphylleia Michx. Berberidaceae. 2 sp. N. Am., Japan.

Diphysa Jacq. Leguminosae (III. 6). 10 sp. Mexico, Cent. Am.

Diplachne Beauv. Gramineae (X). 14 sp. trop. and sub-trop.

Diplacus Nutt. = Mimulus Linn.

Dipladenia A. DC. Apocynaceae (II. 4). 20 sp. S. Am. Most are lianes climbing by hooks—"a circle of blunt spines at the bases of the leaves."

Diplarrhena Labill. Iridaceae (II). 2 sp. S. Austr., Tasm.

Diplopappus Cass. = Aster Tourn.

Diplotaxis DC. Cruciferae (II. 10). 20 sp. Eur., Medit. (2 in Brit.).

Diplusodon Pohl. Lythraceae. 42 sp. Brazil.

Dipsaceae. Dicotyledons (Sympet. Aggregatae). About 150 sp. placed in 5 to 10 genera by different authors; chiefly N. temp., Old World. Most are herbs with opp. exstip. leaves (connate in Dipsacus), and cymes (Triplostegia, Morina) or heads of flowers. That the heads are also cymose (p. 65) is indicated by the fact that the flrs. do not open in strictly centripetal order. The outer flrs. have the corolla more or less drawn out on one side (cf. Compositae, Cruciferae &c.). Bracteoles of the ordinary kind are rare (Triplostegia). Most genera have an epicalyx, a cup-shaped organ springing from the base of the ovary, and usually regarded as composed of the two united bracteoles. K and C 5-merous, or 4-merous by union of two members. Sta. 4, epipetalous. $\overline{G}$ (2), 1-loc. with one pendulous anatropous ovule. Flrs. usually protandrous, of the floral class B′ (p. 91). Fruit an achene (see Compositae) usually enclosed in the epicalyx. Seed with endosperm. Several are cultivated as ornamental plants; Dipsacus yields teasels. *Chief genera:* Morina, Dipsacus, Scabiosa. Placed in Asterales by Benth.-Hooker, in Dipsacales by Warming. (See Sambucus for relationships.)

Dipsacales (Warming). The 7th cohort of Sympetalae.

Dipsacus Linn. Dipsaceae. 12 sp. Medit., Eur., Afr. *D. sylvestris* Mill., the common teasel, in Brit. The connate leaves form troughs round the stem in which rain-water collects; it is very probable that some of this is absorbed by the plant. The protandrous flrs. are chiefly visited by bees. *D. fullonum* L. is the fuller's teasel. The bracts are hooked; the fruit-heads are largely used for raising the nap upon cloth.

Dipteracanthus Nees = Ruellia Linn.

Dipterocarpaceae. Dicotyledons (Archichl. Parietales). 16 gen. with 313 sp., Seychelles to New Guinea, chiefly in India. They are mostly trees with entire leathery stipulate leaves, and racemose infls. of ☿, regular, pentamerous flrs. Receptacle flat or slightly concave. K 5; C, 5 convolute; A 5, 10, 15 or more; $\underline{G}$ (3), 3-loc., with 2 ovules in each loc. Fruit usually a 1-seeded nut, enclosed in the calyx, some of whose leaves grow out into wings serving as an aid in wind-carriage of the seeds. No endosperm. All contain resin-passages. Many are very valuable as timber trees, and in other ways. *Chief genera:* Dipterocarpus, Dryobalanops, Shorea, Vatica, Vateria. Placed in Guttiferales by Benth.-Hooker, in Cistiflorae by Warming.

Dipterocarpus Gaertn. Dipterocarpaceae. 65 sp. India, Ceylon to Philipp. Is. The large amplexicaul stipules protect the young bud (cf. Magnolia, &c.). Several sp. yield wood-oil or Gurjun balsam, a resinous juice obtained by tapping the base of the trunk, and used as a varnish, &c. Many yield useful timber.

Dipteryx Schreb. (*Coumarouna* Aubl.). Leguminosae (III. 8). 8 sp. trop. Am. *D. odorata* Willd. furnishes the fragrant Tonka or Tonquin beans (the seeds) used in snuff, perfumery &c. The fruit is one-seeded and indehiscent.

Disa Berg. Orchidaceae (3). 60 sp. S. and trop. Afr. The median sepal is hood-shaped with a long spur at the back; the labellum is usually small. "In order that insects may reach the copiously stored nectar, they must insert their proboscides on either side of the column; and in accordance with this fact the viscid discs are turned outwards in an extraordinary manner. The pollinia are crooked, and when removed bend downwards by their own weight so that no movement is necessary" (Darwin).

Dischidia R. Br. (incl. *Conchophyllum* Blume). Asclepiadaceae (II. 4). 46 sp. Indo-mal., Polynes., Austr. Epiphytes (p. 173), climbing by adventitious roots, and with fleshy leaves which have a covering of wax. The most interesting sp. is the curious pitcher-plant, *D. Rafflesiana* Wall., which besides the ordinary leaves, has "pitcher-leaves." Each of these is a pitcher with incurved margin, about 10 cm. deep. Into the pitcher grows an adventitious root developed from the stem or petiole just beside it. The pitcher may hang with its mouth upwards or may stand horizontally or upside down. No final explanation of its meaning has yet been made. It usually contains a lot of *débris*, apparently largely carried into it by nesting ants. Most of the pitchers contain more or less rain water, so that very likely they act as humus collectors and water reservoirs for the plant. The inner surface is coated with wax, so that the water cannot be absorbed by the pitcher itself, but must be taken up by the roots. It is also supposed that the pitchers are useful in condensing for re-absorption the vapour transpired by the numerous stomata upon their inner walls.

Developmental study shows the pitcher to be a leaf with its lower side invaginated. The existing sp. of D. illustrate all stages in the process. Many, *e.g. D. bengalensis* Colebr., have bi-convex leaves; others have the under surface concave, *e.g. D.* (*C.*) *Collyris* Wall., and the roots are developed under and sheltered by the concave leaves. From this stage a further invagination would lead to *D. Rafflesiana*. For further details of this interesting genus, see Treub in *Ann. Buitenz.* III. 1883, Haberlandt's *Tropenreise*, p. 168, and two papers in *Ann. of Bot.* 1893.

Dischisma Choisy. Scrophulariaceae (II. 9). 9 sp. S. Afr.

Disciflorae (Benth.-Hooker). The 2nd series of Polypetalae (p. 133).

Disporum Salisb. Liliaceae (VII). 12 sp. N. temp. As. and Am.

Dissochaeta Blume. Melastomaceae (I). 25 sp. Indo-mal., Philippines.

Disteganthus Lem. Bromeliaceae (I). 1 sp. Cayenne.

Distichlis Rafin. Gramineae (X). 4 sp. in salt places, Am. *D. maritima* Rafin. is also found in Austr. and is used for binding sandy soil (cf. Ammophila, Carex).

Ditassa R. Br. Asclepiadaceae (II). 60 sp. S. Am.

Dodartia (Tourn.) Linn. Scrophulariaceae (II. 8). 1 sp. S. Russia, W. As.

Dodecatheon Linn. Primulaceae (IV). 5 sp. N. Am., N.E. As. Like Cyclamen.

Dodonaea Linn. Sapindaceae (II). 46 sp. Austr., Sandw. Is., Madag.

Dolichandrone Fenzl. Bignoniaceae (II). 7 sp. Madag. to Malaya.

Dolichos Linn. Leguminosae (III. 10). 30 sp. trop. *D. Lablab* L. is largely cultivated in the tropics for its edible pods, which are cooked like kidney beans. *D. biflorus* L. the Horse-gram, is cultivated in India, &c. for feeding horses and cattle.

Dombeya Cav. Sterculiaceae. 40 sp. Afr.

Dondia Spreng. = Hacquetia Neck.

Donia G. et D. Don = Clianthus Soland.

Doodia R. Br. Polypodiaceae. 5 sp. Ceylon to Austr.

Dorema D. Don. Umbelliferae (7). 4 sp. W. Centr. As. *D. ammoniacum* D. Don is the source of the gum-ammoniacum used in medicine; it is obtained by puncturing the stem.

Doronicum Tourn. ex Linn. Compositae (VIII). 25 sp. N. temp. Two sp. are naturalised in parts of Britain.

Dorstenia Plum. ex Linn. Moraceae (I). 50 sp. trop. Am., Afr., 1 As., often grown in hot-houses. Herbs or shrubs with peculiar cymose infl. The common receptacle of the flrs. is a flat or hollowed fleshy structure, often more than an inch wide. The flrs. are unisexual, sometimes all of one sex on one receptacle, sometimes intermingled with several males round one female. They are sunk in the receptacle, round whose edge project a number of bracts. The perianth-segments are completely united to one another. Sta. in the ♂ flr. usually 2. The fruit when ripe is shot out of the receptacle; the latter becomes very turgid and presses on the fruit and at length ejects it as one might fillip away a bit of soap between finger and thumb.

Doryalis = Dovyalis E. Mey.

Doryanthes Correa. Amaryllidaceae (II). 3 sp. Austr.

Dorycnium Linn. Leguminosae (III. 5). 10 sp. Medit.

Douglasia Lindl. Primulaceae (I). 3 sp. arctic N. Am., 1 Spain to Italy (alpine, see p. 147).

Dovyalis E. Mey. Flacourtiaceae. 3 sp. S. Afr., Madag. See Aberia. Placed in Bixineae by Benth.-Hooker.

Downingia Torr. (incl. *Clintonia* Dougl.). Campanulaceae (III.). 3 sp. Oregon, Calif., Chili. *D. pulchella* Torr. has no twisting of the floral axis, or not more than 90°.

Draba Dill. ex Linn. Cruciferae (IV. 14). 150 sp. N. temp. and arctic, and south-west. N. Am., 5 in Brit. (whitlow-grass). Most are tufted xerophytes with hairy or fleshy leaves.

Dracaena Vand. Liliaceae (VI). 40 sp. Old World trop. Mostly trees, whose stems branch and grow in thickness (by a peculiar 'extra-fascicular' cambium, see text-books of anatomy). The famous dragon-tree of Teneriffe (*D. Draco* L.), which was blown down in 1868, was 70 ft. high and 45 ft. in girth and was supposed to be 6000 years old. A resin exudes from the trunk of this sp., known as dragon's blood.

Dracocephalum Linn. Labiatae (VI. 3). About 40 sp. Eur., Medit., As., and 1 in N. Am.

Dracontium Linn. Araceae (IV). 6 sp. trop. Am. The sympodial rhizome gives rise yearly to one enormous leaf and an infl. The leaf has 3 chief divisions, and the lateral ones develope dichotomously at first. Flr. ☿ with perianth.

Dracophyllum Labill. (incl. *Sphenotoma* R. Br.). Epacridaceae. 26 sp. N.Z., Austr., New Caled. The sheathing leaves leave ring-scars when they fall.

Dracunculus (Tourn.) Adans. Araceae (VII). 2 sp. Medit. Fertilised like Arum.

Drimia Jacq. Liliaceae (V). 15 sp. Afr.

Drimiopsis Lindl. et Paxt. Liliaceae (V). 5 sp. S. and trop. Afr.

Drimys Forst. Magnoliaceae (3). 10 sp. S. Am., and N. Z. to Borneo. There is a distinction between calyx and corolla (cf. Illicium). The bark of *D. Winteri* Forst. (Winter's bark) is medicinal.

Drosera Linn. Droseraceae. 90 sp. trop. and temp. 3 in Brit. of which *D. rotundifolia* L., the sundew, is abundant in bogs. They are herbs usually with creeping rhizomes and rosettes of leaves. The blade of the leaf is circular in some sp., elongated in others, and is set with curious tentacles; these are emergences (p. 114) containing vascular bundles and ending in swollen reddish heads which secrete a sticky fluid that glistens in the sun like dew. Flies and other insects mistaking it for honey are held by it. The tentacles are exceedingly sensitive to continued pressure even by the lightest bodies; the result is to cause an inward and downward movement of the head of the tentacle, finally placing the fly upon the blade of the leaf. At the same time the stimulus passes to the surrounding tentacles causing them also to bend downwards to the same point. The victim is thus smothered and now the glandular heads of the tentacles secrete a ferment which acts upon the proteids of the insect and brings them into solution, when they are taken up by the leaf. Afterwards the tentacles expand once more and recommence the secretion of the sticky fluid. It has been shown by direct experiment that the food thus obtained is of great benefit to the plant, though it can live without it. By this means D. is able to live in very poor soil where no other flowering plants can live. It is noteworthy that the extra materials thus obtained are devoted chiefly to seed-production. If the stimulus produced by the capture of an insect be very powerful, the leaf itself may bend into a cup form, and this feature is very marked in some sp., the leaves bending almost double over the prey. [See p. 178.]

The flrs. of the Brit. sp. rarely open, but pollinate themselves in the bud. The stigmas are branched each into two lobes.

Droseraceae. Dicotyledons (Archichl. Sarraceniales). 6 gen. with 100 sp. Drosera is a cosmopolitan genus, the rest are more local in distribution. Herbaceous plants, usually with perennial rhizome and rosettes of leaves. Aldrovanda is a water-plant. All are insectivorous plants; Dionaea and Aldrovanda have sensitive leaves which shut up when touched, the others catch their prey by means of sticky tentacles upon the leaves. For details see individual genera. Flrs. usually in cincinni, rarely in racemes or solitary, ☿, regular, 5—4-merous, usually hypogynous. K (5); C 5, imbricate or convolute; A usually 5, pollen in tetrads (cf. Ericaceae). Cpls. 2, 3 or 5, united; placentae usually parietal, rarely axile or free-central; style long; stigmas simple or branched. Ovules 3—∞, anatropous. Loculicidal capsule. Seed with endosperm and small basal embryo. *Genera:* Dionaea, Aldrovanda, Drosophyllum, Drosera, Byblis, Roridula. Placed in Rosales by Benth.-Hooker, in Cistiflorae by Warming.

Drosophyllum Link. Droseraceae. 1 sp., *D. lusitanicum* Link, Morocco, Portugal, S. Spain. The long narrow leaves are provided with glands of two kinds—stalked glands secreting a sticky fluid (cf. Drosera), and sessile ones which only secrete when stimulated by nitrogenous matter, and then secrete a digestive ferment. Insects alight on the glands and are entangled by the sticky secretion; they struggle for a while and finally sink down and die upon the leaf and are digested by the ferment. The taller glands have no power of movement, but are able to secrete a ferment as well as the sessile ones. [See p. 178 and *Bot. Cent.* 60, p. 33.]

Drupaceae (Warming) = Rosaceae (sub-order V).

Dryandra R. Br. Proteaceae (II). 50 sp. Austr. Like Banksia.

Dryas Linn. Rosaceae (III. 6). 2 sp. arctic. *D. octopetala* L. alpine in Brit. It is androdiœcious in the Alps, but probably the ♂ plants are due to poor nourishment (p. 68). The style becomes feathery after fertilisation (cf. Clematis, Geum).

Drymaria Willd. Caryophyllaceae (II. 3). 30 sp. trop. and S. temp.

Drymoglossum Presl. Polypodiaceae. 3 sp. Himal. to Borneo. *D. carnosum* Hk. has succulent leaves.

Drymonia Mart. Gesneriaceae (I). 15 sp. trop. Am., W. Ind.

Dryobalanops Gaertn. f. Dipterocarpaceae. 4 sp. Borneo, Sumatra. *D. aromatica* Gaertn. and other sp. yield Borneo or Sumatra camphor; it is found in the cracks of the wood and is obtained by cutting up the trunk into pieces. It is rarely seen in Europe, being used chiefly in China, where it commands a high price. The young leaves are red, and hang downwards (p. 157).

Duguetia A. St. Hil. Anonaceae (3). 20 sp. trop. S. Am. *D. quitarensis* Benth. and other sp. furnish, it is said, some of the lancewood of commerce. The fruit is formed of the individual berries or achenes united to the fleshy receptacle.

Duranta Linn. Verbenaceae (II). 8 sp. S. Am.

Durio Adans. Bombacaceae. 7 sp. Indo-mal. *D. zibethinus* Murr. produces the durian fruit, well known for its delicate flavour and disagreeable smell.

Duroia Linn. f. Rubiaceae (I. 8). 10 sp. S. Am. The chief interest is the myrmecophilous habit (p. 115). *D. petiolaris* Hk. f. and *D. hirsuta* K. Sch. have stems swollen just below the infl. The swollen part is hollow and entrance is obtained by two longitudinal slits. This curious organ seems to arise spontaneously and is inhabited by ants, which bite through the thin parenchymatous tissue of the slits. *D. saccifera* Benth. et Hk. f., on the other hand, has its 'ant-houses' on the leaves. At the base, upon the under side of each leaf, are two pear-shaped organs formed by outgrowth of the leaf. The entrance is upon the upper side of the leaf, and protected from the rain by a little flap.

Duvaua Kunth = Schinus Linn.

Dyckia Schult. f. Bromeliaceae (3). 6 sp. Brazil.

Dypsis Noronha. Palmae (IV. 6). 6 sp. Madag. (p. 158).

Dysodia Cav. Compositae (VI). 34 sp. Am.

Dysoxylum Blume. Meliaceae. 100 sp. Indo-mal.

Ebenaceae. Dicotyledons (Sympet. Ebenales). 5 gen. with 280 sp. trop. (especially Indo-mal.). Trees and shrubs with alt., opp. or whorled, simple, leathery, usually entire leaves. Flrs. axillary, solitary or in small cymes, regular, usually diœcious, bracteolate, 3—7-merous. K persistent, gamosepalous; C convolute, gamopetalous. Sta. epipetalous at base of tube, usually in 2 whorls but frequently ∞ by branching; staminodes usually present in ♀ flrs., ovary syncarpous, superior, 2—16-loc., with 1—2 anatropous ovules pendulous in each loc. Styles 2—8, free or united below. Fruit usually a berry with fewer seeds than there were formerly ovules, sometimes dehiscent. Embryo straight or slightly curved, in abundant cartilaginous endosperm. Many of these trees yield valuable wood, *e.g.* Diospyros. *Genera:* Royena, Euclea, Maba, Diospyros, Tetraclis. Placed in Ebenales by Benth.-Hooker, in Diospyrinae by Warming.

Ebenales. The 3rd cohort of Sympetalae in Engler's system, the 6th in Bentham and Hooker's system (pp. 131, 134).

Ebenus Linn. Leguminosae (III. 7). 14 sp. Medit.

Ecballium A. Rich. Cucurbitaceae (III). 1 sp. Medit., *E. Elaterium* A. Rich., the squirting cucumber. When ripe the fruit is highly turgid. As it drops from the stalk, a hole is made in its lower end, and through this the contraction of the pericarp squirts the seeds, mixed with a watery fluid. A powerful purgative (elaterium) is prepared from the fruit.

Eccremocarpus Ruiz et Pav. Bignoniaceae (III). 3 sp. Peru. See order. The valves of the fruit hang together at the top.

Echeveria DC. = Cotyledon Linn.

Echidnopsis Hook. f. Asclepiadaceae (II. 4). 4 sp. E. Afr. Xerophytes with succulent stems.

Echinocactus Link et Otto. Cactaceae (I. 1). 200 sp. Texas to Chili. Ribbed cacti (see order).

Echinocereus Engelm. = Cereus Haw.

Echinocystis Torr. et Gray. Cucurbitaceae (IV). 25 sp. Am. Tuberous climbing herbs. *E. lobata* Torr. et Gray is often cultivated. Its tendrils are very sensitive and nutate very rapidly. The tendril becomes straight and erect as it comes round towards the main axis, thus avoiding contact.

Echinophora Tourn. ex Linn. Umbelliferae (4). 8 sp. Medit. One cpl. is aborted. The umbel has one ♀ flr. in the centre, surrounded by ♂ flrs. The spiny stalks of the latter enclose the fruit.

Echinops Linn. Compositae (XI). 75 sp. E. Eur., Afr., As. The spherical head is really compound, formed of a great number of small 1-flowered heads, each with its own involucre. The flrs. are largely visited by bees.

Echinopsis Zucc. = Cereus Haw.

Echinopterys A. Juss. Malpighiaceae (1, but forming a link between 1 and 2, as it has a flat torus). 1 sp. Mexico. Mericarp spiny.

Echinospermum Sw. Boraginaceae (IV. 2). 50 sp. temp. *E. Lappula* Lehm. is often cultivated. The flrs. change colour from white to red and blue (see order). Fruit hooked.

Echites P. Br. Apocynaceae (II. 4). 40 sp. Am.

Echium Tourn. ex Linn. Boraginaceae (IV. 5). 30 sp. Eur., Medit. *E. vulgare* L., viper's bugloss, in Brit. Flr. zygomorphic, protandrous, visited by bees.

Edwardsia Salisb. = Sophora Linn.

Ehretia Linn. Boraginaceae (II). 40 sp. trop., chiefly Old World. Trees and shrubs.

Ehrharta Thunb. Gramineae (VII). 20 sp. S. Afr., 2 Mascar., 2 N. Z. Useful pasture grasses for sandy soil.

Eichhornia Kunth. Pontederiaceae. 5 sp. S. Am. The sympodium is very complex (see *Nat. Pfl.*). Each shoot in turn is pushed to one side by the axillary shoot of its last leaf but one; with this shoot it is combined, however, up to the first leaf of the axillary shoot. After leaving the axillary shoot, each shoot bears another leaf, and then ends in the infl., which is enclosed in a spathe, and which at first glance appears to spring from the stalk of the last leaf. In *E. azurea* Kunth. the flrs. are dimorphic, in *E. crassipes* Solms trimorphic heterostyled. This last sp. has, when floating freely in water, large bladder-like swollen petioles, but if it be grown in soil, these are not nearly so large. Their object is not clearly understood, but they cause the plant to float high in the water and it is easily blown about by wind.

Elaeagnaceae. Dicotyledons (Archichl. Thymelaeales). 3 gen. with 17 sp. found chiefly on steppes and coasts of the N. Hemisph. They are much branched shrubs, often with leathery leaves, which are entire, opp. or alt., and covered, as are all parts of the plants, with scaly hairs. There are frequently thorns on the surface (reduced shoots). Infl. racemose. Flrs. ☿ or unisexual, 2- or 4-merous. In the ♂ the receptacle is often flat, but in the ☿ or ♀ flower it is tubular as in Thymelaeaceae, and may be fused with the ovary. No petals. Sta. as many, or twice as many as sepals. Cpl. 1 with one erect anatropous ovule. Fruit a pseudo-drupe. Seed with little or no endosperm. *Chief genera:* Hippophaë, Elaeagnus. Placed in Daphnales by Benth.-Hooker, in Thymelaeinae by Warming.

Elaeagnus (Tourn.) Linn. Elaeagnaceae. 12 sp. As., Eur., N. Am. (the oleaster). The fruit of some sp. is edible, and the plants are grown in shrubberies.

Elaeis Jacq. Palmae (IV. 7). 2 sp., one in trop. Am., the other, *E. guineensis* Jacq. in trop. Afr. The latter is the oil-palm, from whose fruits the palm-oil, so largely used for railway axles &c., is obtained by boiling.

Elaeocarpaceae. Dicotyledons (Archichl. Malvales). 7 gen. with 120 sp. trop. and sub-trop. Trees and shrubs with alt. or opp., stipulate leaves, and racemes, panicles or dichasia of flrs. Disc usually present. K 4 or 5, free or united, valvate; C 4 or 5, rarely united, the petals often much divided at the ends, valvate or imbricate but never convolute. Flr. often apetalous. Sta. ∞, free, on the disc, which is sometimes developed to an androphore; anthers 2-loc., usually opening by two pores (sometimes confluent) at the apex. Ovary sessile, with 2—∞ (rarely 1) loc. Ovules in each loc. ∞ or 2, anatropous, pendulous with ventral raphe. Style simple, sometimes lobed at apex. Fruit a capsule or drupe. Embryo straight, in abundant endosperm. *Chief genera:* Elaeocarpus, Sloanea, Aristotelia. The E. are united to Tiliaceae by Benth.-Hooker and Warming; the grounds upon which they are separated in *Nat. Pfl.* are chiefly anatomical.

Elaeocarpus Burm. ex Linn. Elaeocarpaceae. 60 sp. trop.

Elaeodendron Jacq. f. Celastraceae. 30 sp. As., Austr., S. Afr., trop. Am. Included in Cassine in *Nat. Pfl.*

Elaterium Jacq. f. Cucurbitaceae (IV). 12 sp. trop. Am. The fruit is explosive like that of Ecballium.

Elatinaceae. Dicotyledons (Archichl. Parietales). 2 gen. with 30 sp. trop. and temp. Undershrubs, herbs, or annual water-plants; the latter are able to live on land, altering their structure to suit the changed conditions (see p. 20 and cf. Littorella &c.). Leaves opp. or whorled, simple with interpetiolar stipules. Flrs. ☿, regular, solitary or in dichasia, 2—6-merous. Calyx hypog., free or united. Corolla imbricate. Sta. in 2 whorls, or inner aborted. Ovary syncarpous, superior, multiloc., with simple style. Placentae axile. Ovules ∞, anatropous. Capsule septifragal. Seed straight or curved. Endosperm thin or none. *Genera:* Bergia, Elatine. Placed in Guttiferales by Benth.-Hooker, in Cistiflorae by Warming.

Elatine Linn. Elatinaceae. 14 sp. trop. and temp. *E. hexandra* DC. and *E. Hydropiper* L., the water peppers or pipe-worts, in Brit. (rare).

Elatineae (Benth.-Hooker) = Elatinaceae.

Elatostema Forst. Urticaceae. 50 sp. Indo-mal. and E. As.

Eleocharis R. Br. Cyperaceae (I). 80 sp. cosmop. *E. palustris* R. Br. is common on turfy moors in Brit. The green tissue is centric (p. 182). The tubers of *E. tuberosa* Schult. (E. As.) are used as food.

Elephantopus Linn. Compositae (I). 16 sp. trop. Am., W. Afr.

Elettaria Maton. Zingiberaceae. 1 sp. India to Java, *E. Cardamomum* Maton. The flrs. are borne on leafless shoots springing from the rhizome. The dried seeds are known as Cardamoms, and are used as a condiment.

Eleusine Gaertn. Gramineae (XI). 6 sp. trop. and sub-trop. *E. coracana* Gaertn. is used as a cereal, and several are useful fodder-grasses.

Elisma Buchen. Alismaceae. 1 sp. Eur. (incl. Brit.), Syria, *E. natans* Buchen.

Ellisia Linn. Hydrophyllaceae. 4 sp. N. Am.

Elodea Michx. Hydrocharitaceae. 6 sp. Am., of which the chief is *E. canadensis* Michx., the American water-weed, which arrived in Brit. about 1842 and rapidly spread over almost all the inland waters of western Europe. Only the ♀ plant is known in Europe, and all the spreading is therefore due to vegetative multiplication chiefly by the breaking off of twigs. It is a submerged plant, slightly rooted, with whorls of leaves, in whose axils are found the squamulae usual in this group of plants. The ♂ flower has P 6, A 9; it breaks off as a bud and comes to the surface (cf. Vallisneria), where it opens. The ovary of the ♀ flr. grows to such a length as to bring the flr. to the surface, where it is pollinated. It has P 6, staminodes 3, $\overline{G}$ (3), and is enclosed below in a 2-leaved spathe. The plant is very hardy and does not form a true winter bud; the leaves are merely a little more closely grouped together.

Elymus Linn. Gramineae (XII). 30 sp. temp. *E. arenarius* L., the lyme grass, occurs on sand-dunes in Brit. (cf. Ammophila and see p. 186); its leaves are coated with wax, but do not roll up in dry air.

Embelia Burm. f. Myrsinaceae (II). 60 sp. trop.

Embothrium Forst. Proteaceae (II). 5 sp. Andes, Chili, E. Austr.

Emex Neck. Polygonaceae (I. 2). 1 sp. Medit., S. Afr., Austr. The fruit is surrounded by the perianth, 3 of whose leaves are spiny.

Empetraceae. Dicotyledons (Archichl. Sapindales). 3 gen. with 4 sp., widely scattered over the N. Hemisph. and in the Andes. They occupy similar positions to the Ericaceae, and have a heath-like habit. The leaves are incurved backwards, forming a cavity on the under side, into which the stomata open, and which is partly filled up by hairs. The infl. is racemose and usually dioecious. In all but Corema the flrs. are on 'short shoots' which arise laterally from the main axis and bear only scales below the infl. K 3, C 3, A 3, $\underline{G}$ (2—9). Loculi = cpls.; ovules 1 in each, anatropous or nearly campylotropous, erect on axile placenta, with ventral raphe. Fruit a drupe with 2—9 stones. Seed albuminous with no caruncle. The nearest related orders are Euphorbiaceae and Celastraceae or Buxaceae, but the family has been placed in various positions by different authors, *e.g.* by Benth.-Hooker (p. 136). *Genera:* Corema, Empetrum, Ceratiola.

Empetrum (Tourn.) Linn. Empetraceae. The only sp., *E. nigrum* L. the crow-berry, is found on moors in the N. temp. zone (incl. Brit.) and in the Andine chain. For habit, flr., &c., see order. The flr. is dioecious and anemophilous, but it sometimes is ☿ and protandrous, and is said to be visited by flies.

Enantioblastae (Warming). The 4th cohort of Monocotyledons.

Encephalartos Lehm. Cycadaceae. 12 sp. Afr. The Kaffirs prepare a meal from the pith (cf. Cycas).

Entada Adans. Leguminosae (I. 5). 11 sp. trop. *E. scandens* Benth. is a common climber of trop. Am. Its pods, which are about 4 feet long, are sometimes carried to Eur. by the Gulf Stream.

Entelia R. Br. Tiliaceae. 1 sp. N. Z. (p. 148). The wood is very light, and is used for floats, &c.

Epacridaceae. Dicotyledons (Sympet. Ericales). 21 gen. with about 320 sp., found chiefly in Austr. and Tasmania, where they represent the Ericaceae of other continents, but extending also to India, N. Z., and S. Am. They resemble the Ericaceae (sect. IV.) closely in habit and appearance, being mostly small shrubs, sparingly branched, with narrow, entire, rigid leaves, usually alternate. Sometimes the leaves are sheathing, in which cases either no scar is left on the stem when the leaf falls, or a ring mark is left, as in Dracophyllum. The flrs. are usually in terminal racemes or spikes, ☿, actinomorphic. K 5, C (5), A 5, hypogynous at edge of disc, or more often epipetalous; the anthers opening by one central longitudinal slit and without horns or other appendages; pollen simple or in tetrads. $\underline{G}$ (5) cpls. opposite petals, placentae axile; ovules in each loc. 1—∞, anatropous, usually pendulous. Style simple, sometimes in depression of top of ovary, with a capitate stigma. Fruit a capsule or stony drupe. Embryo straight, in copious endosperm. *Chief genera:* Sprengelia, Richea, Dracophyllum, Epacris, Styphelia. Placed in Ericales by Benth.-Hooker, in Bicornes by Warming.

Epacrideae (Benth.-Hooker) = Epacridaceae.

Epacris Forst. Epacridaceae. 30 sp. S.E. Austr., N.Z., New Caled. They are much cultivated in greenhouses for their flrs.

Ephedra Tourn. ex Linn. Gnetaceae. 20 sp. warm temp. Shrubs, much branched, with opp. connate leaves reduced to scales, so that the stem performs the work of assimilation (p. 166). Flrs. diclinous, with no trace of cpls. in ♂, or of sta. in ♀. ♂ flrs. in spikes, the ♀ in pairs or solitary, usually bracteate. The ♂ flr. has a perianth of 2 antero-posterior united leaves, beyond which the axis is prolonged and bears 2—8 sessile 2-locular anthers. The ♀ has a tubular perianth and one erect orthotropous ovule with a long micropyle projecting at the top of the flr.; the flr. or flrs. are enclosed by bracts which become red and fleshy after fertilisation and enclose the fruit. The seed is enclosed in the perianth, which becomes woody, and the fleshy bracts cover this again. There are two cotyledons in the embryo; the seed is albuminous. For further details see *Nat. Pfl.*, and art. Gymnospermae.

Epidendrum Linn. Orchidaceae (13). Over 400 sp. trop. Am., many epiphytic. The labellum is often more or less united to the column, and a canal runs from the junction right down into the ovary.

Epigaea Linn. Ericaceae (II. 4). 2 sp., *E. asiatica* Maxim. in Japan, *E. repens* L., the trailing arbutus or mayflower, in the atlantic U.S. (p. 146). The flrs. are tetramorphic (Darwin, *Forms of Flrs.* p. 297).

Epigynae (Benth.-Hooker). The 2nd series of Monocotyledons.

Epilobium Dill. ex Linn. Onagraceae (II). 160 sp. temp. and arctic; 9 in Brit. (willow-herbs). The flr. is regular, but in some sp. slightly zygomorphic by the bending of sta. and style (p. 74), which project so as to make a landing-place for insects. Of the Brit. sp. several may be noticed, as the flrs. form an interesting series in regard to cross-pollination, &c. (cf. Phacelia, Geranium, &c.). In *E. angustifolium* L. the flrs. are large and autogamy almost impossible. Honey is secreted by the upper surface of the ovary. The sta. are ripe when the flr. opens, and project horizontally, whilst the style, with its stigmas closed, is bent downwards. Afterwards the sta. bend down and the style up, and the stigmas open. This is the plant in which C. K. Sprengel (1793, see biography in *Nat. Science*, 1893) made the first discovery of dichogamy. In *E. hirsutum* L. sta. and stigma are ripe together, but the stigma projects beyond the sta.; if not pollinated it bends back and touches the anthers. *E. parviflorum* Schreb. is a small-flowered sp., rarely visited by insects; 4 sta. are shorter, 4 longer, than the style; the former are only useful for cross-pollination, the latter self-pollinate the flr. Sta. and stigma ripen simultaneously. The seed of E. is provided with a tuft of hairs for wind-carriage.

Epimedium (Tourn.) Linn. (excl. *Vancouveria* C. Morr. et Dcne.). Berberidaceae. 10 sp. N. temp. Old World. *E. alpinum* L. is naturalised in Brit. It has, like most E., a 2-merous flr., which is pendulous, with glandular hairs on the stalk. It is protogynous, and after a time the valves of the anthers bend upwards and roof over the stigma, and the male stage begins. Finally self-pollination occurs by the elongation of the style carrying the stigma among the valves. The nectaries are of a curious shoe-like pattern. The seeds have a membranous aril.

Epipactis Adans. Orchidaceae (4). 10 sp. N. temp.; 2 in Brit., *E. latifolia* All., and *E. palustris* Crantz (helleborine). There are two staminodes at the sides of the column; the anther is acrotonic. The labellum has a hinged terminal portion, which by its rebound causes the insect to fly somewhat upwards in leaving the flr. In so doing it rubs the rostellum, which instantly becomes very viscid and cements the pollinia (which have no true caudicles) to the insect. The chief visitors are wasps (p. 92). See Darwin's *Orchids*, p. 93.

Epiphyllum Haw. Cactaceae (I. 1). 4 sp. Brazil, often epiphytic.

Epipogum S. G. Gmel. Orchidaceae (4). 1 sp. Eur. (incl. Brit.), As., *E. aphyllum* Sw. a leafless saprophyte (p. 177) with a branched rhizome and no roots; it has an endotropic mycorhiza (p. 39). Flr. as in Epipactis, but without any twisting of the receptacle.

Epipremnum Schott. Araceae (II). 8 sp. Indo-mal.

Episcia Mart. Gesneriaceae (I). 30 sp. trop. Am.

Equisetaceae. Pteridophyta (Equisetineae). An order with only one surviving genus (Equisetum, *q.v.*), but formerly well represented upon the earth. Many large fossil forms (Calamites, &c.) are known.

Equisetineae. One of the main divisions of Pteridophyta (*q.v.*), containing the single order Equisetaceae.

Equisetum Linn. Equisetaceae (the only genus). 25 sp. temp. and arctic; 9 in Brit. (horsetails), chiefly in swampy places. They are perennial herbs with sympodial rhizomes, which send up aerial shoots each year. These may be of one or two kinds; in some sp. the ordinary green shoot bears the reproductive spike at the end, while in others there is a special reproductive shoot, usually appearing early in the year, and often without chlorophyll, the ordinary shoots performing assimilating work only. The stem is very distinctly jointed, and at the nodes are borne whorls of united leaves, closely pressed against the stem, and of little or no use in assimilation. The branches emerge through the leaf-sheath and thus appear at first sight endogenous in origin (p. 38); in reality they are exogenous, but formed so much later than the leaves that their points of origin are already covered by the leaf-sheath, and so they are compelled to burrow through it. Stages in this process may easily be observed. The surface of the stem is grooved; the ridges are occupied by mechanical tissue, whilst the green tissue and stomata are at the base of the furrows. This is a marked xerophytic structure (p. 166) and is repeated very closely in Casuarina. In several sp. the internodes of the rhizome are swollen into tubers, which serve for hibernation and vegetative propagation.

The spike is very like the ♂ flr. of a Conifer, and has as much right to the title of flower. It consists of an axis with short internodes, bearing a densely packed mass of sporophylls. Each is shield-shaped and bears a number of sporangia upon the under side of the head (*i.e.* towards the stem), arranged like the horses of a 'merry-go-round.' The spores are of one kind only; each has, running round it, two spiral cuticularised bands of membrane, formed from the outer wall and termed *elaters*. These are hygroscopic, unfolding in damp air. In the rolling up again on drying, the elaters of one spore become entangled with those of others and cause them to adhere together, so that several prothalli may be formed near to one another when they germinate upon the soil. This is very necessary, for the prothalli are diœcious, though so far as we can tell the spores are all alike. The prothallus is fairly large, the male being smaller than the female.

The stems of *E. hyemale* L. are used for polishing under the name of Dutch rushes; the cell-walls of the mechanical tissues contain much silica, as do also those of most sp.

For further details, see Pteridophyta, and Campbell's *Mosses and Ferns*.

Eragrostis Host. Gramineae (x). 100 sp. mostly subtrop.

Eranthemum Linn. (excl. *Pseuderanthemum* Radlkf.). Acanthaceae (IV. A). 17 sp. trop. As.

Eranthis Salisb. Ranunculaceae (2). 7 sp. N. temp. *E. hyemalis* Salisb., the winter aconite, is naturalised in Brit. It has a thick rhizome or row of tubers, one formed each year. The flrs. appear in February, before the leaves, and are solitary and terminal. Each has an involucre of three green leaves, a 'calyx' of 6 segments, and several honey-leaves or petals.

Eremia D. Don. Ericaceae (IV. 10). 30 sp. Cape Col.

Eremurus Bieb. Liliaceae (III). 20 sp. alpine, W. and Cent. As. The flr. is protogynous; the petals crumple up before the essential organs are ripe. The leaves of *E. aurantiacus* Baker are eaten in Afghanistan.

Eria Lindl. Orchidaceae (21). 80 sp. trop. As. Epiphytes.

Eriachne R. Br. Gramineae (IX). 22 sp. trop. As., Austr.

Erianthus Michx. Gramineae (II). 17 sp. trop.

Erica (Tourn.) Linn. Ericaceae (IV. 9). 420 sp. Eur. (esp. Medit.) and S. Afr. (see order). 5 sp. occur in Brit. The two common heaths, *E. cinerea* L. and *E. Tetralix* L., cover great areas of moor; the others are rarities of Cornwall and Ireland. In habit E. resembles Calluna. The flr. is bell-shaped and pendulous, visited and fertilised mainly by bees. Honey is secreted by the disc, and insects hanging on to the flr. and probing for it, must shake the sta. and receive a shower of the loose powdery pollen from the pores in the tips of the anthers. In the wider mouthed sp. the anthers have horn-like projections at the back, which ensure contact with the insect's proboscis. The stigma projects beyond the sta. so as to be touched first.

Many S. Afr. sp. are cultivated in greenhouses. *E. scoparia* L. is the common heath of S. France &c., growing several feet high. It is known as Bruyère and its rootstocks furnish 'briar' wood pipes. The roots of heaths possess an endotropic mycorhiza.

Ericaceae. Dicotyledons (Sympet. Ericales). A family of about 50 gen. and 1350 sp. Owing to their numbers and their social habit of growth the E. form very characteristic parts of the vegetation in many portions of the globe. They are found in most parts of the world except in deserts and in hot damp tropical regions. The *Ericoideae* are confined to Africa, Medit. and Europe, the two great masses of them being however separated by the Sahara, though sp. of Erica &c. occur in each. Another peculiar phenomenon is that those sp. of *Andromedeae* with north circumpolar distribution (*e.g. Andromeda polifolia*) have their nearest allies in trop. and sub-trop. floras (see Drude in *Nat. Pfl.* or *Pflanzengeog.* for a full discussion of the interesting distribution of E. See also the genera, esp. Rhododendron, Vaccinium, Calluna, Erica).

The distribution of E. on arctic moors and swamps and on dry moors in warmer regions (almost all of them grow in peaty soil) would lead us to expect the presence of xerophytic characters in them; and such is indeed the case, especially in *Ericoideae*. The family consists of woody plants varying in size from small undershrubs to large shrubs or even trees. Two types of habit may be distinguished—that of *Ericoideae* and that of the remaining tribes. In the latter there are usually true winter-buds formed (*e.g.* Rhododendron), even though the leaves may last over the winter. The bud is covered with scale leaves, and when its elongation occurs these drop off and a gap is left on the stem; the foliage leaves tend to form rosettes at the ends of the twigs. The leaves themselves are generally elliptical, entire or nearly so, and leathery, frequently hairy. The upper epidermis is stoutly cuticularised, and there is very often water storage tissue between it and the green tissue. In the *Ericoideae* there are no true winter-buds or scale-leaves; the plants are evergreen, and the whorled leaves needle-like, often through being rolled back on themselves to form a groove or even a chamber on the under side (cf. Empetrum, and see p. 166).

The infl. commonly terminates a strongly growing shoot, and a sympodial growth tends to be formed. The flrs. may be solitary, but are more often in racemose groupings, each with a bract and two bracteoles, ☿, actinomorphic or slightly zygomorphic. K 4—5; C (4—5) or 4—5 (*Ledeae*), usually bell-shaped; A 8—10, obdiplostemonous, hypogynous or rarely slightly epipetalous; anthers introrse, often with projecting appendages, the thecae often spreading at top, and opening by apical pores; pollen grains in tetrads. Below the gynœceum is a fleshy disc secreting honey. G (4—5) superior or inferior, 4—5-locular, with axile placentae; ovules in each loc. 1—∞, anatropous; style simple with capitate stigma. Fruit a capsule, drupe or berry. Embryo cylindrical, in copious endosperm.

The flrs. of the Brit. sp. are mostly bee-flrs. with a 'loose-pollen' mechanism. The hanging position and the size of the flower are suited to bees. The stigma projects so as to be first touched, and in probing for the honey at the base of the flr. the bee touches the sta. or their projecting horns, and by thus shaking them causes a shower of pollen to fall upon itself from the tips of the anthers. Calluna is partly anemophilous; Kalmia has a curious explosive mechanism (see C., K., and Erica, &c.).

Bentham and Hooker separate *Vaccinioideae* from the E. and make of them an independent order, on account chiefly of the inferior ovary. They add to the E. as here defined, the Pyrola group of Pyrolaceae (*q.v.*).

Classification and chief genera (after Drude).

I. *RHODODENDROIDEAE* (septicidal capsule; seed with ribbed loose coat, often winged; corolla falling after flowering; sta. with upright or long adnate anthers, with no appendages):

1. *Ledeae* (polypet.): Ledum.
2. *Rhododendreae* (zygomorphic): Rhododendron, Menziesia.
3. *Phyllodoceae* (actinomorphic): Loiseleuria, Kalmia, Phyllodoce, Daboecia.

II. *ARBUTOIDEAE* (berry or loculicidal capsule; seed triangular or ovate, not winged; corolla falling; anthers much folded, with peg-like appendages, or prolonged into tubes, shedding the pollen upwards; ovary superior):

4. *Andromedeae* (dry capsule with small calyx at base): Cassiope, Andromeda, Epigaea.

5. *Gaultherieae* (fruit a capsule or berry; calyx fleshy round capsule, or leafy; anthers blunt at tip or with two short processes): Gaultheria, Pernettya.
6. *Arbuteae* (calyx as small disc at base of berry; anthers with two long processes): Arbutus, Arctostaphylos.

III. *VACCINIOIDEAE* (as II., but ovary inferior):

7. *Vaccinieae* (ovary sharply defined from peduncle): Gaylussacia, Vaccinium.
8. *Thibaudieae* (calyx decurrent on ovary and going over into peduncle): Pentapterygium, Agapetes, Paphia, Macleania, Thibaudia.

IV. *ERICOIDEAE* (fruit usually a loculicidal capsule or a nut; seeds round, not winged; corolla persistent after flowering; anther with short connective, thecae spreading above, frequently appendaged):

9. *Ericeae* (> 1 seed in each loc.): Calluna, Erica.
10. *Salaxideae* (1 seed in each loc., capsule or nut): Eremia, Salaxis.

[The E. belong to the cohort termed Ericales by Benth.-Hooker and Engler, Bicornes by Warming.]

Ericales. The 1st cohort (Engler) of Sympetalae (p. 130). The 4th cohort (Benth.-Hooker) of Gamopetalae (p. 134).

Erigeron Linn. Compositae (III). 150 sp. cosmop., chiefly N. Am.; 2 in Brit. (flea-bane).

Erinus Linn. Scrophulariaceae (III. 10). 1 sp. Pyrenees, Alps (p. 149).

Eriobotrya Lindl. Rosaceae (II. 4). 10 sp. sub-trop. As. The fruit of *E. japonica* Lindl. is a favourite dessert fruit in the East (loquat).

Eriocaulaceae. Monocotyledons (Farinosae). 6 gen. with 340 sp. mostly trop. and sub-trop. (see Eriocaulon). Perennial herbs with grass-like leaves. Flrs. in heads (involucrate), inconspicuous, unisexual, 2- or 3-merous, regular or zygomorphic. Perianth usually sepaloid, in 2 whorls. ♂ flr. with 4 or 6 sta. (3 or 2 in Paepalanthus); anthers di- or mono-thecous. ♀ flr. with superior ovary of (2—3) cpls., with one orthotropous pendulous ovule in each loc. Fruit a capsule. Endosperm. *Chief genera:* Eriocaulon, Paepalanthus. [Placed in Enantioblastae by Warming, in Glumaceae by Benth.-Hooker.]

Eriocauleae (Benth.-Hooker) = preceding.

Eriocaulon Linn. Eriocaulaceae. 110 sp. trop. and sub-trop. *E. septangulare* With. occurs in the eastern U.S. and also in the Scottish Hebrides and the west coast of Ireland (the only representative of the order in Eur.).

Eriocephalus Linn. Compositae (VII). 19 sp. S. W. Afr.

Eriochloa H. B. et K. Gramineae (V). 5 sp. trop. and sub-trop. Fodder-grasses.

Eriodendron DC. (*Ceiba* Medic. *q.v.*). Bombacaceae. 9 sp. trop., chiefly Am. *E. anfractuosum* DC., the silk-cotton tree, has its seeds enveloped in silky hairs, which are used for stuffing cushions, &c. [See Kingsley's *Westward Ho*, c. XXI.]

Eriogonum Michx. Polygonaceae (I. 1). 120 sp. N. Am., chiefly western U.S. The genus differs much from most of the order, having no ocreae, and having cymose umbels or heads of flrs. The partial infl. consists of a few or many flrs. surrounded by a special involucre formed of united bracts. The partial infls. are combined in various ways into heads &c.

Eriolaena DC. Sterculiaceae. 8 sp. E. Ind.

Eriophorum Linn. Cyperaceae (I). 12 sp. N. temp. chiefly on turf moors (p. 182). 4 sp. in Brit. (cotton-grass or cotton-sedge). The ☿ flrs. are massed together; each has a perianth of bristles which after fertilisation grow out into long hairs surrounding the fruit and acting as a means of distribution. The hairs are sometimes used in stuffing pillows &c.

Eriophyllum Lag. Compositae (VI). 12 sp. N. W. Am.

Eriosema DC. Leguminosae (III. 10). 70 sp. trop. and sub-trop.

Eriospermum Jacq. Liliaceae (III). 25 sp. chiefly Cape Colony.

Eriostemon Sm. Rutaceae (III). 16 sp. Austr., New Caled.

Eritrichium Schrad. (incl. *Cryptantha* Lehm.). Boraginaceae (IV. 2). 90 sp. temp.

Erodium L'Hérit. Geraniaceae. 50 sp. temp. (2 in Brit.—Stork's-bill). Like Geranium. The awn twists into a corkscrew-form with a free end and is very hygroscopic. The mericarp has a sharp point with backward pointing hairs. It falls on the ground, frequently point downwards, and the free end of the awn catches against surrounding objects. If dampness supervene, the awn untwists and so lengthens: the free end being entangled, the fruit is driven into the soil. When dry the awn once more curls up, and the process may be repeated (cf. Stipa).

Erophila DC. Cruciferae (IV. 14). 4 sp. Eur., Medit. (1 Brit. *E. vulgaris* DC.). Included in Draba in *Nat. Pfl.*

Eruca Tourn. ex Adans. Cruciferae (II. 10). 10 sp. Medit. Oil is obtained from the seed of *E. sativa* Mill.

Erucastrum Presl = Brassica Tourn.

Ervum Tourn. ex Linn. = Vicia Tourn. For *E. Lens* L. see Lens.

Eryngium (Tourn.) Linn. Umbelliferae (3). About 150 sp. trop. and temp. (exc. S. Afr.). 2 sp. in Brit. (Eryngo or sea-holly) on the sea-shores. They are prickly herbs with thick roots and fleshy leaves coated with wax (p. 186). Flrs. in cymose heads, blue and largely visited by bees. Fibre (Caraguata fibre) is obtained from the leaves of *E. pandanifolium* Cham. et Schlecht.

Erysimum (Tourn.) Linn. Cruciferae (IV. 16). 80 sp. Medit., Eur., As. (*E. cheiranthoides* L., treacle mustard, in Brit.)

Erythraea Renealm. Gentianaceae (I. 2). 30 sp. temp. *E. Centaurium* Pers., the common centaury, occurs in Brit. in many varieties.

Erythrina Linn. Leguminosae (III. 10). 30 sp. trop. and subtrop. *E. crista-galli* L. is a favourite in cultivation. Its bright red flrs. are inverted; the wings are nearly aborted; the keel forms at its base a honey sac. Probably humming-birds are the visitors. *E. indica* Lam. is largely planted as a shade for coffee and other plants, and as a support for pepper. *E. caffra* Thunb., the Kaffir-boom, furnishes a very light timber.

Erythrochiton Nees et Mart. Rutaceae (V). 5 sp. trop. Am. The infl. springs from the surface of a leaf, owing to adnation (p. 30).

Erythronium Linn. Liliaceae (V). 7 sp. N. temp.

Erythrophleum Afzel. Leguminosae (II. 1). 5 sp. Afr., China, N. Austr. *E. guineense* G. Don is the red-water tree of Sierra Leone. "The bark is a powerful poison and is used by the native tribes as an ordeal. A red juice flows from the tree, which is used for the same purpose."

Erythroxylaceae. Dicotyledons (Archichl. Geraniales). 2 gen. with 90 sp. trop. Nearly allied to Linaceae, in which they are placed by Benth.-Hooker. Flr. regular, ☿; K 5, C 5, A 5 + 5 united at base, G (3 or 4), usually 1-loc. Ovules 1 or 2, pendulous. Drupe. Endosperm. *Chief genus:* Erythroxylon.

Erythroxylum P. Br. Erythroxylaceae. 90 sp. trop. and subtrop., chiefly Am. *E. Coca* Lam. (Peru), the coca, is the chief sp. The leaves are infused like tea or chewed with lime and enable the person using them to undergo great fatigue. Cocaine, used as a local anaesthetic, is prepared from them. Many sp. have heterostyled flrs.

Escallonia Mutis. Saxifragaceae (V). 50 sp. S. Amer., chiefly Andine. Shrubs with alternate, leathery, gland-dotted leaves. Ovary inferior, 2—3-loc., with twice as many placentae and ∞ ovules.

Escalloniaceae (Warming). An order of Saxifraginae, included in Saxifragaceae by other authors.

Eschscholzia Cham. Papaveraceae (2). 10 sp. western U.S., often cultivated as border flowers. The receptacle is concave, so that the flr. is perigynous. In dull weather each petal rolls up on itself, enclosing and protecting some of the sta. The ripe fruit explodes and scatters the seeds; each valve as it dries has a tendency to roll up spirally, and thus a great tension is set up (p. 111).

Esenbeckia H. B. et K. Rutaceae (V). 10 sp. trop. Am., W. Ind.

Espeletia Mutis. Compositae (V). 11 sp. Andes. Characteristic plants of the alpine region (Paramo). Aloe-like xerophytes with dense covering of hairs (see Goebel, *Pflanzenbiol. Schild.*).

Eucalyptus L'Hérit. Myrtaceae (2). 140 sp. Austr., 2 or 3 Indo-mal. One of the most characteristic genera of the Austr. flora (blue-gum, iron-bark, stringy bark, blood-wood, &c.). Some sp. reach an enormous size, *e.g.* *E. amygdalina* Labill. which has been found 450 ft. high and 90 ft. in girth. The leaves at first formed are opposite and dorsiventral, the later ones alternate and isobilateral, and thus more suited to the climate. The floral receptacle is hollow and becomes woody in the fruit. The calyx is thrown off as a lid when the flr. opens.

On account of their rapid growth and economic value, these trees are now largely cultivated in India, Algeria, &c. Many sp. yield valuable timber; *E. Globulus* Labill. (blue-gum) yields oil of eucalyptus; others yield oils, kino, &c.

Eucharis Planch. et Linden. Amaryllidaceae (I). 6 sp. Columbia. The sta. spring from the margin of the corona (see order).

Euchlaena Schrad. Gramineae (I). 1 sp. Mex., *E. mexicana* Schrad. Very like Zea in habit and infl. The ♀ spikelets are free from one another and do not form a 'cob.' It is used as a cereal in Cent. Am.

Eucnide Zucc. = Mentzelia Linn.

Eucomis L'Hérit. Liliaceae (V). 5 sp. S. Afr. The dense spike of flrs. is crowned by a tuft of bracts.

Eucryphiaceae. Dicotyledons (Archichl. Parietales). 1 gen., Eucryphia, with 4 sp. S. Am., Austr. Placed in Rosaceae, near to Quillaja, by Benth.-Hooker. See *Nat. Pfl.*

Eugenia Mich. ex Linn. (incl. *Jambosa* DC., *Syzygium* Gaertn.). Myrtaceae (I). 625 sp. trop. Many sp. have edible fruit, *e.g. E. malaccensis* L., the rose-apple or Malay apple. The dried flr.-buds of *E. caryophyllata* Thunb. form the well-known spice cloves.

Eulophia R. Br. Orchidaceae (16). 50 sp. trop.

Eunomia DC. = Aethionema R. Br.

Euonymus Linn. Celastraceae. 60 sp. N. temp., and S.E. As. *E. europaeus* L., the spindle-tree, in Brit. Several sp. have curious outgrowths of cork upon their stems. The flrs. are polygamous and protandrous. On the ripe seed is a bright red fleshy aril, serving in bird-dispersal. The development of the aril may easily be studied by examining seeds of various ages. The wood is used for spindles, pegs, &c., and furnishes good charcoal.

Eupatorium (Tourn.) Linn. (incl. *Conoclinium* DC.). Compositae (II). 400 sp. mostly Am., a few in Eur., As., trop. Afr. *E. cannabinum* L., hemp-agrimony, in Brit. Its flrs. are largely visited by butterflies.

Euphorbia Linn. Euphorbiaceae (A. II. 8). 600 sp. chiefly sub-trop. and warm temp. (12 in Brit.). They differ very much in vegetative habit. The British sp. of spurge are herbs and so are many others, but shrubs are also frequent. The chief interest centres in those sp. that inhabit very dry places and have consequently a xerophytic habit. Most of these forms closely resemble Cactaceae (q.v.), and sometimes when not in flr. it is very difficult to decide from the outside appearance whether one has to do with a Euphorbia or a Cactus. The presence of latex of course distinguishes the former. It is very interesting to see how similar conditions of life have called forth, in three different orders not nearly allied to one another, such a similarity of habit as is seen in Euphorbia, the Cactaceae, and

Stapelia (Asclepiadaceae). As in the cacti, we get almost spherical forms, ridged forms, cylindrical forms, &c. Many are armed with thorns. In all cases it is the stem which is fleshy. The outer tissue is green and does the assimilating work of the plant; the inner portion of the stem consists mainly of parenchymatous storage tissue.

The best accessible account of the morphology of E. is that of Goebel (*Pflanzenbiol. Schild.* p. 56), from which the following is abstracted. He divides the plants roughly into the following groups:

I. Leaves normal, well developed, serving a long time as assimilative organs. (1) Shoot not water-storing: *e.g.* the British sp. (2) Storage in tubers below ground: *E. tuberosa* L. (3) Stem as reserve for water, &c., but not green: *E. bupleurifolia* Jacq. (cylindrical stem covered with corky scales = leaf bases. Leaves borne in wet season, drop off in dry). (4) Stem fleshy, green, leafy in wet season only: *E. neriifolia* L., &c.

II. Leaves abortive, dropping off early. Assimilation and storage carried on in stem. Various types occur here (cf. Cactaceae) approaching more or less nearly to a perfectly spherical form. Some common ones are (1) *E. Tirucalli* L. (Zanzibar), with thin cylindrical shoots. *E. pendula* Link is very similar and closely resembles Rhipsalis in the Cactaceae. (2) *E. xylophylloides* Brongn. has flattened shoots (cf. Phyllanthus § *Xylophylla*, and Epiphyllum in Cactaceae). (3) *E. Caput-Medusae* L. has a stout stock giving off a number of thinner branches at the top. These are covered with little cushion-like papillae, closely crowded, which are really leaf bases; the leaf proper is undeveloped. Many sp. show this structure. (4) *E. mamillaris* L. has a thorn in the axil of each cushion (= a metamorphosed infl.-axis). If the cushions, as in the cacti, become 'fused,' we get a ridged stem, as is seen in (5) *E. polygona* Haw. (cf. *Echinopsis cereiformis* in Cactaceae), *E. grandicornis* and many others. Most of these sp. exhibit pairs of stout thorns which are the stipules of the abortive leaves. By the two horizontal thorns one can tell one of these plants from a cactus, which has a group of thorns. (6) *E. meloformis* Ait. is nearly spherical but ribbed, whilst in (7) *E. globosa* Sims (cf. Echinocactus) we have an almost perfect sphere. [The student should read at the same time the art. Cactaceae, and Stapelia, and compare all these succulent forms with one another. See also Goebel, *loc. cit.*]

Besides the above, mention may be made of *E. splendens* Boj. and *E. Bojeri* Hook., plants with thick stems and green leaves, the latter being dropped in the dry season.

The other chief point of interest in E. is the *cyathium*, or infl. condensed to simulate a single flr. The resemblance is almost perfect. The general branching of the plant is cymose (dichasial). The partial infl. forms a cyathium by the non-development of its internodes, the absence of the perianths of the individual flrs. and the reduction of each ♂ flr. to one sta. There is a perianth-like organ of 5 leaves, really bracts, and between these are 4 curious horn-like bodies (U-shaped in fig.), which are the combined stipules of the bracts. Then follow a number of sta. arranged with the oldest nearest to the centre and each with a peculiar joint half-way up the stalk. In the middle of the cyathium is a 3-carpelled ovary on a long stalk. This is usually ripe for pollination before any of the sta. ripen.

Diagram of central cyathium of infl. of *Euphorbia Peplus* L. (after Eichler, modified).

That this cyathium is an infl. and not a flr., consisting of a lot of ♂ flrs., each of 1 sta., round a single ♀ flr., is shown by several facts, *e.g.* the centrifugal (cymose) order of ripening of the organs, and the joint on the sta.; at this point in the allied genus Anthostema, there is a perianth, which shows that the sta. is really a reduced ♂ flr.

In *E.* § *Poinsettia* the infl. is rendered conspicuous by the bright red colour of the larger upper bracts. These sp. are often cultivated as showy conservatory plants.

The fruit explodes when ripe; the carpels split off from the central axis and open at the same moment.

Euphorbiaceae. Dicotyledons (Archichl. Geraniales). 220 gen. with 4000 sp., cosmop., except in the arctic regions. Few sp. have a very wide range; the most widely-ranging genus is Euphorbia itself. Benth.-Hooker place E. in Incompletae, but it is closely related to Geraniales by the structure of the gynœceum, &c., although separated a good deal from the other orders of the cohort by the amount of reduction that has occurred in most of its flrs.

Most E. are shrubs or trees, a few herbaceous (*e.g.* the Brit. sp.). Many are xerophytes; a number of Australian sp. are of ericoid habit (p. 166); the S. Afr. sp. of Euphorbia are cactus-like; others resemble Lauraceae, or possess phylloclades (*e.g.* Phyllanthus sp.). A few are lianes. The leaves are usually alternate; some have opposite leaves, some opposite leaves above and alternate below. Stipules are usually present, but may be represented by branched hair-like bodies (Jatropha), glands, or thorns. Nearly all E. contain latex in special laticiferous cells.

The infl. is usually complex; almost every type occurs. Often the first branching is racemose and all subsequent ones cymose. In some cases, *e.g.* Dalechampia and Euphorbia (*q.v.*), the partial infls. are so condensed as to give the appearance of single flrs. The flrs. are always unisexual, monœcious or diœcious, regular, hypogynous. The perianth may be present as two whorls; more often there is only one (calyx) and frequently the flr. is naked. The perianth is usually 5-merous. Sta. 1—∞, free or united in various ways. Ricinus has branched sta. *Phyllanthus cyclanthera* has the sta. united, with a ring-like common anther. $\underline{G}$ usually (3), with axile placentae, and 3 loc. Styles usually 2-lobed. The ovules are constant throughout the family and form its best distinctive feature; they are 1 or 2 in each loc., collateral, pendulous, anatropous, with ventral raphe. The micropyle is usually covered by a caruncle, which is also found on the seed. The fruit is almost invariably a 'schizocarp-capsule.' It splits into cpls. often elastically, and at the same time each cpl. opens ventrally, letting the seed escape. Seed albuminous.

Most E. are poisonous. Several are important economic plants, *e.g.* Manihot (rubber, cassava), Hevea (rubber), Croton, Ricinus, &c.

Classification and chief genera (after Pax):

A. PLATYLOBEAE (cotyledons much broader than radicle):

I. *PHYLLANTHOIDEAE* (ovules 2 per loc.; no latex):

1. *Phyllantheae* (embryo large, little shorter than endosperm; ♂ calyx imbricate): Phyllanthus.
2. *Bridelieae* (do., but ♂ calyx valvate): Bridelia.
3. *Daphniphylleae* (embryo short, 4—6 times shorter than endosperm): Daphniphyllum.

II. *CROTONOIDEAE* (ovules 1 per loc.; latex usually present):

1. *Crotoneae* (sta. bent inwards in bud): Croton.
2. *Acalypheae* (sta. erect in bud; flr. usually apetalous; ♂ calyx valvate; infl. a raceme, spike, or panicle, axillary or terminal): Mercurialis, Acalypha, Ricinus, Dalechampia.
3. *Jatropheae* (do.; infl. a dichasial panicle): Hevea, Jatropha.
4. *Manihoteae* (do.; infl. a simple terminal spike or raceme): Manihot.
5. *Cluytieae* (♂ calyx imbricate; ♂ flrs. with petals, in groups or cymes, these partial infls. axillary or in complex infls.): Codiaeum.
6. *Gelonieae* (do. but apetalous): Gelonium.
7. *Hippomaneae* (do.; apetalous; infl. axillary or terminal, spike-like, the partial infls. cymes): Stillingia, Hura.
8. *Euphorbieae* (cyathium): Anthostema, Euphorbia.

B. STENOLOBEAE (cotyledons as wide as radicle):

I. *PORANTHEROIDEAE* (ovules 2 per loc.): Poranthera.

II. *RICINOCARPOIDEAE* (ovules 1 per loc.): Ricinocarpus.

[E. are placed in Unisexuales by Benth.-Hooker, in Tricoccae by Warming.]

Euphrasia Linn. Scrophulariaceae (III. 12). 50 sp. extra-trop. *E. officinalis* L. (eyebright) is common in Brit. Semi-parasites with loose-pollen flrs. (see order). The 4 anthers lie close under the upper lip of the flr.; the two upper cohere together and also the upper on each side to the lower on the same side; the lower lobe of each anther has a projecting spine. Insects probing for honey shake these spines and receive upon their heads a shower of pollen from among the anthers. The stigma protrudes beyond the sta. in most flrs. so as to be touched first, but every stage can be found from highly protogynous flrs. with very protruding stigmas to almost homogamous flrs. whose stigma does not protrude and where self-fertilisation is the rule.

Eurya Thunb. Theaceae. 36 sp. Mexico, S. Am., W. and E. Ind.

Euryale Salisb. Nymphaeaceae (III). 1 sp. S. E. As. Flr. epigynous. The seeds and roots are eaten in China.

Eurybia Cass. = Olearia Moench.

Eurycles Salisb. Amaryllidaceae (I). 2 sp. N. Austr., Malaya.

Eusporangiatae. See Filicineae.

Euterpe Gaertn. Palmae (IV. 6). 10 sp. trop. Am. *E. edulis* Mart., the Assai palm, yields an edible fruit; a nutritious beverage is prepared from it by soaking the fruit in water.

Eutoca R. Br. = Phacelia Juss.

Evodia Forst. Rutaceae (I). 45 sp. trop., exc. Am.

Evolvulus Linn. Convolvulaceae (I. 2). 80 sp. trop. and sub-trop.

Exacum Linn. Gentianaceae (I. 1). 30 sp. Old World trop. The style is bent to one side or other of the flr.; both arrangements occur on the same plant (see p. 75).

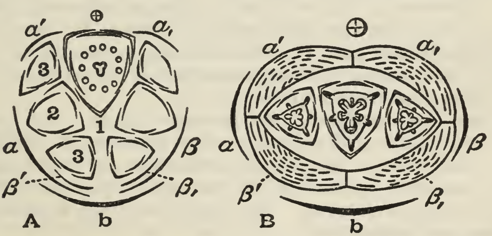
Excœcaria Linn. Euphorbiaceae (A. II. 7). 30 sp. trop., exc. Am. For *E. sebifera* Muell.-Arg. see Sapium.

Exogonium Choisy = Ipomœa Linn.

Faba (Tourn.) Linn. = Vicia Linn.

Fadyenia Hook. Polypodiaceae. 1 sp. *F. prolifera* Hook., W. Ind. The sterile leaves produce buds at the tips.

Fagaceae. Dicotyledons (Archichl. Fagales). 5 gen. with 350 sp.; there are three chief centres of distribution—Fagus, Castanea § *Eucastanea* and Quercus in N. extra-trop. regions, Pasania and Castanopsis in trop. As. and Calif., Fagus § *Nothofagus* in S. Am., N. Z.,



Floral diagrams of *Castanea vulgaris*, after Eichler. A, diagram of ♂ cyme in axil of catkin-leaf, the sta. and rudimentary gynœceum only shown in the first flr. The sequence of the flrs. is indicated by the figures 1, 2, 3. B, diagram of ♀ partial infl. b = bract, $\alpha\ \beta$ = bracteoles, $\alpha'\ \beta'\ \alpha_{,}\ \beta_{,}$ = bracteoles of second order.

and S. Austr. Most are trees with simple leaves and scaly stipules that drop off as the leaves expand. The flrs. come out in the axils of the leaves of the current year and are diclinous and anemophilous. They are arranged in catkins or small spikes (exc. Fagus ♂). In general there is a close resemblance to Betulaceae, and, as in that order, the flrs. are usually in dichasial cymes in the axils of the catkin-leaves; there are often, however, more than three flrs.

Perianth bract-like, (4—7). ♂ flr. with as many to twice as many or ∞ sta. undivided, with or without rudimentary style. ♀ flrs. usually in dichasia of 3 in Castanea, 2 in Fagus, 1 in Quercus &c. $\overline{G}$ usually (3) with 3 styles (exc. sp. of Castanea); loculi 3, usually visible before fertilisation. Placentae axile, each bearing 2 pendulous anatropous ovules with 2 integuments. Fruit a 1-seeded nut. Seeds without endosperm.

The group of nuts is surrounded by a cup-like organ termed a *cupule*; in the oak there is one nut in each cupule, in the beech two, in the chestnut three. About the morphology of this organ there has been much discussion. Eichler (see diagram above, fig. B, and *Blüthendiagr.*) regards it as the combined bracteoles α' β' α, β, Prantl (Engler's *Bot. Jahrb.* VIII. 1887) as an axial outgrowth. See also Celakovsky in *Pringsheim's Jahrb.* XXI. 1890, and cf. Betulaceae. The cupule only becomes clearly visible after fertilisation.

Some of the F. show signs of peculiar development of the embryo-sac, and other interesting features (see Chalazogamae).

The order includes several important economic plants, chiefly valuable for their timber, *e.g.* oak (Quercus), beech (Fagus), chestnut (Castanea), &c.

Classification and genera (after Prantl):

1. *Fageae* (flrs. in dichasia, rarely solitary in axils of foliage-leaves; lateral and single fruits 3-angled): Fagus (incl. Nothofagus).
2. *Castaneae* (♀ flrs. in dichasia or single in the axils of catkin-leaves; fruit rounded at sides): Castanea, Pasania, Quercus.

[Benth.-Hooker unite F. with Betulaceae, as Cupuliferae, placing them in Unisexuales; Warming places them in Querciflorae.]

Fagara Linn. = Zanthoxylum Linn.

Fagopyrum Tourn. ex Hall. Polygonaceae (II. 4). 2 sp. As. The flrs. resemble those of Polygonum, but are heterostyled, with long and short-styled forms (p. 95). *F. esculentum* Moench is the buckwheat, largely cultivated, especially in N. Am., for its fruit (seed), in which there is a floury endosperm. The plant is also used as green fodder, and is a good honey-plant.

Fagraea Thunb. Loganiaceae. 20 sp. E. Ind. to Austr., often epiphytic. Some sp. have nectaries at the outside of the base of the flr. These attract ants which are said to prevent bees from boring holes in the flr. to rob the honey (p. 92).

Fagus (Tourn.) Linn. (incl. *Nothofagus* Blume). Fagaceae (1). The genus forms 2 sections, § *Eufagus* with 4 sp. N. temp. and § *Nothofagus* with 12 sp. antarctic S. Am., N. Z. and S. Austr. *F. sylvatica* L., the beech, is found in Brit. and over large parts of Eur. It often forms homogeneous forests, and is accompanied by a peculiar undergrowth, *e.g. Asperula odorata*, *Lathrea squamaria*, &c. (see Höck in *Bot. Centr.* 52, p. 353, 1892). The ♂ flrs. are in pendulous cymose heads, the ♀ in pairs; each cupule encloses two nuts. The wood of the beech is hard, and is much used in the arts; an oil is expressed from the nuts. It forms hedges in many districts; when growing low it does not drop its leaves, as it does when it takes the tree form, and thus a beech-hedge affords good shelter in winter for gardens &c. A variety with red sap in the cells of the epidermis is often cultivated in parks under the name copper-beech. The beech only flowers every few years, and saves up material in the interval (cf. Agave). *F.* (*N.*) *Cunninghami* Hook., the myrtle-tree (Austr.) is an evergreen sp. largely cultivated in Austr. &c.

Falcaria Riv. ex Rupp. Umbelliferae (5). 1 sp. Eur., As.

Falkia Linn. f. Convolvulaceae (I. 1). 4 sp. Afr.

Faradaya F. Muell. Verbenaceae (IV. 4). 5 sp. Austr., Polynes.

Faramea Aubl. Rubiaceae (II. 18). 100 sp. trop. S. Am., W. Ind See Müller's *Fert. of Flrs.* p. 304 (dimorphic pollen).

Farinosae (Engler). The 7th cohort of Monocotyledons (p. 126).

Farsetia Turra (incl. *Fibigia* Medic.). Cruciferae (IV. 18). 19 sp. Medit.

Fatsia Dcne. et Planch. (incl. *Echinopanax* Dcne. et Planch., and *Tetrapanax* C. Koch). Araliaceae. 3 sp. China, N. W. Am. *F. papyrifera* Benth. et Hook. f. is the rice-paper tree of China. The paper is made from the pith, which is split into thin sheets and pressed (cf. Cyperus).

Fedia Gaertn. Valerianaceae. 1 sp. Medit., *F. Cornucopiae* Gaertn. For other sp. see Valerianella.

Feronia Correa. Rutaceae (X). 1 sp. India to Java, *F. elephantum* Correa, the Elephant-apple or Wood-apple. The wood is useful, and the tree yields a gum, used instead of gum-arabic. The fruit is edible.

Ferula Tourn. ex Linn. Umbelliferae (7). 80 sp. Medit., Cent. As. *F. communis* L. is often cultivated in shrubberies under the name of giant-fennel. It only flowers after storing up materials for some years (cf. Fagus, Agave). *F. Narthex* Boiss. and *F. Assa-foetida* Linn. are the sources of the drug Asafoetida, obtained by notching the roots and collecting the escaping juice. It is used as a condiment in Persia &c. under the name 'food of the gods,' and as a stimulant in medicine. *F. galbaniflua* Boiss. et Buhse and *F. rubricaulis* Boiss. are the sources of the gum galbanum, used in medicine.

Festuca (Tourn.) Linn. Gramineae (X). 90 sp. cosmop.; 5 in Brit. (fescue-grass). The leaves roll up inwards in dry air like those of Stipa. Many are good pasture-grasses. The sp. when growing on mountains are commonly viviparous (see order).

Feuillea Gled. = Fevillea Linn.

Fevillea Linn. Cucurbitaceae (I). 6 sp. trop. Am. The 5 sta. are all alike.

Fibigia Medic. = Farsetia Turra.

Ficaria (Dill.) Hall = Ranunculus Linn.

Ficoidales (Benth.-Hooker). The 14th cohort of Polypetalae (p. 134).

Ficoideae (Benth.-Hooker) = Aizoaceae.

Ficus Tourn. ex Linn. Moraceae (II). 600 sp. trop., chiefly in E. Ind. and Polynes., &c. A very important genus of trees and shrubs of the most various habit. In general they possess alternate entire leaves, with stipules which envelope the bud (acting as a protection to it against heat, &c.) and soon after their unfolding drop off altogether. Adventitious roots are very common. The simplest way, perhaps, of dealing with the great variety of form will be to consider one by one some of the commonest sp.

F. elastica Roxb., the indiarubber tree, usually grows as a stout independent tree, but sometimes epiphytically like *F. benjamina*, reaching often very considerable dimensions. At its base (see figs. in *Nat. Pfl.*) are developed buttress-roots, radiating out in all directions; their depth is often several feet, while their thickness is only a few inches. From the branches are given off adventitious roots which grow downwards, enter the soil, branch out, and suck up nourishment. These grow in thickness and form great pillars supporting the branches. The leaves are entire, and leathery in texture, with a glossy surface which refuses to be wetted; their apex is not provided with a 'drip-tip' (see *F. religiosa*, below). The stipules protect the bud. Caoutchouc is obtained from the latex by cutting notches in the tree bark after it is at least 25 years old.

F. indica L. and *F. benghalensis* L. show similar habit. The latter is the famous banyan tree. Its aerial roots form supporting pillars, and, if allowed to establish them freely, the tree may reach immense size, covering a great area. (It is sacred in India, and the roots are provided with tubes of bamboo to protect them, and the ground is prepared for them.) See plate in *Nat. Pfl.*

F. religiosa L. (the Peepul or Bo-tree) is similar, but its leaves have a long acuminate apex, combined with an easily wetted surface. From the apex the rain drips off rapidly after a shower and the leaf is soon dry. In the very wet tropical forests of E. India, &c., this property is of some importance to the plant (see Stahl, Regenfall und Blattgestalt, *Ann. Buitenz.* 1893, or abstract by Miss Lorrain Smith in *Nat. Science*, 1893).

F. Sycomorus L., the true sycomore or mulberry fig, and *F. Carica* L. the fig, are also erect trees.

F. repens Rottl. is a small climbing sp. which takes hold of its support by aerial roots (as in ivy); these secrete a gummy substance containing caoutchouc, and then absorb the fluid constituents, leaving the caoutchouc as a cement, fastening the roots to their support (Darwin, *Climbing Plants*, p. 185).

F. Thwaitesii Mig. and other climbing sp. are heterophyllous, the leaves on the climbing shoots being small and of different shape to those on the erect shoots.

F. Benjamina L. and other sp. climb up other trees giving off aerial clasping (negatively heliotropic) roots which surround the trunk of the support. These roots thicken and unite into a network and finally often strangle the 'host' altogether. These sp. often become epiphytic by the dying away of their lower portions, but, like the Aroids they maintain their communication with the ground by long aerial roots. Sometimes they commence as epiphytes and send down aerial roots to the soil.

The infl. is hollowed out, and consists of a number of flrs. inside a pear-shaped common receptacle, which opens by a narrow mouth at the top. Within the mouth, in most sp., are the ♂ flrs., while the rest of the cavity is filled with ♀ flrs. (see Sachs, *Physiol.* p. 434, and figs. in *Nat. Pfl.*). The ♂ has a perianth and 1 or 2 sta., the ♀ a smaller perianth. The infl. as a whole is protogynous. The mode of pollination is very extraordinary (cf. Yucca), there being a special insect (Blastophaga, a small wasp) adapted to Ficus flrs. The gravid female enters a fig infl. and lays eggs in the ovaries; the male wasps thus formed fertilise the females and these as they emerge are pollinated by the ♂ flrs. and carry the pollen to new figs. For further details and an account of the peculiar process of 'caprification,' see Müller's *Fert. of Flrs.* p. 521, *Nat. Pfl.*, Cunningham on *F. Roxburghii* (rev. in *Bot. Centr.* 45, p. 344), and papers in *Bot. Jahrb.* II. 1890, p. 245.

Many sp. bear the flrs. on old parts of the stem (p. 156). The fruit is a multiple fruit, composed of a lot of drupes inside the common fleshy receptacle; that of *F. Carica* L. is the common fig.

Lac (shellac, &c.) is produced on several sp. by the punctures of a small hemipterous insect (cf. Butea). Several sp. yield caoutchouc, obtained by notching the stems. The buttress-roots are used as planks by the natives.

Filago Linn. Compositae (IV). 12 sp. Eur., As., Am., N. Afr.; 3 in Brit.

Filices. The Ferns proper or Homosporous Leptosporangiate Filicineae (see below).

Filicineae. One of the main divisions of Pteridophyta. They are characterised by well-developed leaves, with vigorous growth, often of large size and much branched. The stem is usually short in proportion to the leaf area, and is not much branched. The sporangia are borne on the leaves and are usually very numerous.

Classification:

A. *EUSPORANGIATAE* (sporangium derived from a group of superficial cells; homosporous; stem simple; sporangia usually sunk in tissue of sporophyll, or in synangia on its surface):

N. O. 1. Ophioglossaceae. 2. Marattiaceae.

B. *LEPTOSPORANGIATAE* (sporangium derived from single superficial cell):

a. Homosporous (*Filices*):

N. O. 1. Osmundaceae. 2. Gleicheniaceae. 3. Hymenophyllaceae. 4. Schizaeaceae. 5. Cyatheaceae. 6. Polypodiaceae.

b. Heterosporous (*Hydropterideae*).

N. O. 1. Marsiliaceae. 2. Salviniaceae.

Bower detaches the Ophioglossaceae to form a separate class, Ophioglossales, and divides Filicales thus:

Simplices (sporangia of simultaneous origin, large sessile, with usually 128 or more spores): Marattiaceae, Osmundaceae, Schizaeaceae, Gleicheniaceae, Matoniaceae.

Gradatae (sporangia in basipetal succession on ± elongated receptacle, sessile or stalked, spores typically 64): Loxsomaceae, Hymenophyllaceae, Cyatheaceae, Dicksoniaceae, Dennstaedtiaceae, Hydropterideae (?).

Mixtae (sporangia of various ages intermixed, small, stalked; spores 64 or less): Davalliaceae, Lindsayaceae, Polypodiaceae.

For further details see the next two articles, Pteridophyta, &c., and the orders. Cf. also *Nat. Pfl.*; Hooker and Baker, *Synopsis Filicum*; Christ, *Die Farnkräuter der Erde*, 1897; Bower, *Studies in the Morphology of Spore-producing members*, *Phil. Trans.*, recent years; Campbell, *Mosses and Ferns*; anatomical papers in recent years of *Ann. of Bot.*; Scott, *Fossil Botany*, &c.

Filicineae Eusporangiatae. The two families (Ophioglossaceae and Marattiaceae) which form this section differ much in detail, but agree in the mode of formation of the sporangia from a group of epidermal cells. Formerly they were classed as higher and more specialised than the Leptosporangiatae, but it is now agreed that they are really the older group (Campbell, *Mosses and Ferns*, pp. 295, 516).

Their exact relationships to one another and to the other members of the vegetable kingdom are difficult to discover, for we have to deal with a few surviving branches of a stock whose maximum development occurred ages ago, and these branches are widely separated in character both from each other and from other groups of plants.

The prothallus in the M. is green and resembles that of the Leptosporangiatae, while in the O. it is subterranean, only exceptionally reaching the surface and turning green (cf. Lang in *Ann. of Bot.* XVI, 1902). It lives for a long time. The antheridia and archegonia are sunk in the tissue of the prothallus. The two orders show great differences in the habit and structure of the sporophyte. The stem is sometimes a creeping rhizome, sometimes a stock which is closely covered by the bases of the leaves. Upon these the sporangia are borne. In the M. they are formed on the under side of ordinary foliage leaves, but in the O. the leaf divides some way above the base into a ventral spike bearing sporangia, and a dorsal 'sterile' portion or green blade. The sporangia also differ in the two orders (*q.v.*). Both are homosporous.

Classification:

Order 1. *Ophioglossaceae:* sporangia on special spike, borne on ventral side of leaf.

2. *Marattiaceae:* sporangia on ordinary foliage leaves, usually combined into synangia.

To these various authors, *e.g.* Campbell (*loc. cit.*), add the *Isoetaceae* as a heterosporous group. In this work they are treated as belonging to Lycopodineae, but their systematic position is exceedingly doubtful.

Filicineae Leptosporangiatae. [See above for relationship to other F.] We shall deal with the two groups separately.

1. *Homosporous F. L.* These plants are generally known as Ferns; only a few of the other groups of F. come in popular estimation under this title. An outline of the general life history will be found under Pteridophyta, but a few details must be added here.

The fertilised ovum on the prothallus developes directly and without any resting period into a fern-plant. There is no intermediate period of rest as there is in flowering plants when the seed is ripe. The prothallus continues to assimilate food and supply the young fern until the latter is able to do so for itself. The primary root remains small or withers away, and new ones are adventitiously formed from the stem or from the leaf bases, as the plant continues to grow. The mature plant may be of almost any size from the tiny filmy ferns (Hymenophyllum) to the large tree ferns (*e.g.* Cyathea, Alsophila). The stem grows by an apical cell, 2- or 3-sided, cutting off segments on each face alternately. From these segments by further divisions arise the tissues and members of the plant. The leaves form a little way behind the growing apex as in flowering plants. One segment (but not every one) gives one leaf: the leaf grows by an apical cell also. The stem may be erect, or may climb (as in many epiphytes), or creep on the surface, or below it as a rhizome. Its growth is slow and branching infrequent. The leaves are borne upon it, the internodes being as a rule short in erect, long in creeping stems. The phyllotaxy is not so definite as in flowering plants, but the leaves are very commonly in ranks or straight lines dependent on the position of the segments cut off from the apical cell of the stem. The lateral buds arise either on the leaf (as in Nephrodium) or on the stem; in the latter case they are rarely axillary, but usually beside the leaf.

The growing tips of stem and leaf are often protected by brown scales, which are mere trichomes or superficial outgrowths.

The leaf is usually large, with apical growth and circinate (coiled) vernation. The growth often lasts for a long time, or even permanently (Lygodium). The leaf blade is usually branched pinnately.

The reproductive organs are borne upon the leaves. The unit is the sporangium or spore capsule, a small rounded body, stalked in orders 5 and 6 (below) but sessile in the others. The capsule has a wall one cell thick, and in this is a group of cells with peculiarly thickened cell-walls, termed the *annulus*, by whose agency (its cells being hygroscopic) the opening of the sporangium is effected. Sometimes, as in many Polypodiaceae, the opening is explosive, and the contained spores are violently ejected. The mechanism is in principle similar to that by which anthers dehisce or certain seed-capsules open. The annulus may have various forms (see the orders, below) but the commonest is that of a row of cells running round the sporangium for about $\frac{3}{4}$ of its circumference.

The sporangia are usually collected into groups termed *sori*. The sorus may be naked, but is more usually covered by an *indusium*. In some cases, *e.g.* Pteris, this is merely a fold of the leaf itself, but more commonly it is a special outgrowth from the leaf, either epidermal or derived from the more deeply placed layers of tissue as well. The sori are usually found on the veins of a leaf, often in the angle where a vein forks. They do not as a rule occur on all the leaves. Very often certain leaves are fertile, the others not. In this case the fertile leaves have usually no green tissue at all, their pinnae being entirely covered with sori, *e.g.* Osmunda sp. In other cases, *e.g.* Aneimia sp., one part of a leaf is sterile, the other fertile. Or again the sori, and this is most common, may be borne simply on the ordinary leaves. They are almost always on the lower surface only; they may entirely cover it, but more often are localised. Into the vexed question of the evolutionary origin of sporangia we cannot enter here.

The spores are all of one kind and if sown under suitable conditions give rise to *prothalli*; these are flat green expansions living for a short or long period independently upon the soil (numbers of them may be seen wherever ferns are growing). On the under surface are borne the reproductive organs of both sexes, *antheridia* (male) and *archegonia* (female). The spermatozoids swim to the ova in the water which collects under the prothali during rain. The fertilised ovum developes directly into a new fern-plant.

Two interesting modifications of the life cycle as above described are known. In *Pteris cretica, Nephrodium Filix-mas*, *Aspidium falcatum* and *Todea africana*, there occurs *apogamy* or the omission of the sexual process from the life-history (see diagram in art. Pteridophyta). The new fern-plant is produced from the prothallus by a process of budding; a growing point developes from the cells of the prothallus. The cycle thus runs:

Fern-plant → sporophylls → sporangia
↑ ↓
← . . . . . . ← prothallus

The other case, *apospory*, is found in *Athyrium Filix-fœmina* var. *clarissima*, and in *Polystichum angulare* var. *pulcherrimum*, &c. Here spore-formation is replaced by a process of budding, which gives rise to prothalli on the backs of the leaves, so that the life-cycle runs

Fern plant → . . . . →
↑ ↓

$$\text{fertilised ovum} \leftarrow \left\{\begin{array}{ll}\text{spermatozoid} & \leftarrow \text{antheridium} \\ \text{ovum} & \leftarrow \text{archegonium}\end{array}\right\} \leftarrow \text{prothallus}$$

This latter case must not be confused with the 'vivipary' of *Asplenium bulbiferum*, &c., where the leaf-tissue buds out directly into new plants, which for a time remain attached to the parent, but ultimately drop off and grow independently. This case is analogous to that of many phanerogams (see p. 113, and cf. Bryophyllum &c.).

Natural History of Ferns. A very large number of ferns are shade- and moisture-loving plants. This is comprehensible enough when we remember how dependent they are on water for their fertilisation. Many however are xerophytes and alpine forms with reduced transpiration. These exhibit the familiar characters (see Ch. III.) of such plants—reduced surface, thick cuticle, hairiness, incurving of leaves (cf. Ericaceae), and even, though but rarely, succulence (*Polypodium adnascens*, *Drymoglossum carnosum*, &c.). The tree ferns and many others have water storage tissue in the stem.

Many sp. are epiphytic, especially in the tropics, though wherever the air is sufficiently damp they may be found growing in this way, even in Britain (p. 173). The most interesting epiphyte is Platycerium; see also Polypodium &c.

The spores of ferns, consisting only of one cell, are of course much lighter than is possible for a seed, and may be carried by wind to enormous distances. Owing to this the ferns of to-day are much more widely distributed than the flowering plants—species for species; and further, owing to the greater age of the family in geological time, it is as a family more widely distributed than the families of flowering plants.

Classification (after Campbell): there are 6 orders:

1. *Osmundaceae* (sporangia shortly stalked with a group of peculiarly shaped cells at one side of the apex; they open by a longitudinal fissure on the other side; fertile and sterile pinnae).
2. *Gleicheniaceae* (sporangia sessile, 3 or more in a sorus without

indusium, with complete transverse annulus and longitudinal dehiscence; creeping rhizome; leaves dichotomous).

3. *Hymenophyllaceae* (sporangia with oblique or transverse complete annulus, opening by longitudinal fissure; they are marginal with a cup-shaped indusium; stem slender, often creeping; mesophyll usually one cell thick).
4. *Schizaeaceae* (sporangia sessile with cap of thick-walled cells at apex instead of a ring-like annulus, and with longitudinal dehiscence; indusium or none; sporangiferous pinnae usually in spikes or panicles).
5. *Cyatheaceae* (sporangia shortly stalked with complete oblique excentric annulus; sorus naked or with cup-like indusium; mostly tree-ferns).
6. *Polypodiaceae* (sporangia stalked with vertical incomplete annulus, and dehiscing transversely).

For relationship, see art. Filicineae.

2. *Heterosporous F. L.* (*Hydropterideae* or *Rhizocarpae*). The two orders of which this group is composed, though they have much in common, are almost certainly derived from different stocks amongst the ferns. For details reference should be made to the orders.

As in the homosporus forms, so here the embryo gives rise directly to a new leafy plant. This is usually aquatic in habit, and exhibits a creeping stem with a dorsiventral arrangement of the leaves. Roots may or may not be formed. The stem grows by means of an apical cell. The sporangia are enclosed in capsular structures termed *sporocarps*. In the Salviniaceae this body contains one sorus only, in the Marsiliaceae more than one. The sorus in the former is composed of one kind of sporangium only, in the latter usually of both. The spores germinate in water; the megaspore gives rise to a small green female prothallus which remains enclosed in the burst spore. Its free surface bears a few archegonia. The microspore gives rise (sometimes without escaping from the sporangium) to a rudimentary male prothallus and an antheridium. From the latter the spermatozoids escape and swim to the female organ.

Classification:

Order 1. *Salviniaceae* (sporocarps unilocular).
2. *Marsiliaceae* (sporocarps plurilocular).

For general relationships, see Filicineae.

Fimbristylis Vahl. Cyperaceae (I). 200 sp. chiefly trop.

Fistularia Linn. = Rhinanthus Linn.

Fitzroya Hook. f. Coniferae (Arauc. 2a; see C. for genus characters). 2 sp. Chili, Tasm.

Flacourtia (Comm.) L'Hérit. Flacourtiaceae. 15 sp. trop. As., Afr. *F. Ramontchi* L'Hérit., the Madagascar plum, and others have edible drupes.

Flacourtiaceae. Dicotyledons (Archichl. Parietales). 70 gen. with 500 sp. of trop. (a few subtrop.) trees and shrubs. They have mostly alt. stip. leathery leaves, frequently more or less two ranked. The flrs. are solitary or in racemose, cymose, or mixed infls., and are very commonly unisexual. The axis is convex, and between petals and sta. it forms a disc or gives rise to various effigurations, commonly glands or scales. The flr. is 4—5- (or more) merous, usually regular, sometimes apetalous. Sta. ∞, sometimes united into ante-petalous groups, the anthers almost always opening by lateral slits. Ovary superior or semi-inferior, 1-loc., with 2—8 (usually 3—5) parietal placentae, which often project far into the cavity. Ovules ∞, always anatropous. Styles as many as placentae, or united. Fruit usually a capsule or berry. Embryo straight, in copious endosperm. *Chief genera:* Erythrospermum, Oncoba, Homalium, Myroxylon, Azara, Flacourtia, Casearia. Benth.-Hooker and Warming unite F. to Bixineae.

Flagellaria Linn. Flagellariaceae. 2 sp. trop. Afr., As., Fiji.

Flagellariaceae. Monocotyledons (Farinosae). 3 gen. (Flagellaria, &c.) with 8 sp., trop. Afr., As., Indo-mal., &c. See *Nat. Pfl.*

Fleurya Gaudich. Urticaceae (1). 8 sp. trop.

Flindersia R. Br. Rutaceae (VII). 12 sp. E. Austr., New Caled., Amboina. Placed in Meliaceae by Benth.-Hooker.

Foeniculum Tourn. ex Linn. Umbelliferae (6). 3 sp. Medit., Eur. *F. vulgare* Mill. (fennel) on sea-cliffs in Brit. The fruit of *F. officinale* All. is used as a condiment and the young leaves are eaten as a vegetable.

Fontanesia Labill. Oleaceae (I. 1). 1 sp. Sicily to Palestine.

Forestiera Poir. Oleaceae (I. 3). 14 sp. Am.

Forskohlea Linn. Urticaceae (5). 5 sp. Medit., Afr., E. Ind.

Forsythia Vahl. Oleaceae (I. 2). 2 sp. China, often cultivated against walls.

Fothergilla Murr. Hamamelidaceae. 2 sp. Kashmir and atlantic N. Am. Flrs. apetalous; sta. numerous.

Fouquieria H. B. et K. Tamaricaceae. 3 sp. Mex., Calif., Texas. Shrubs with deciduous leaves, whose midrib persists and forms a thorn (cf. Caesalpinia, Combretaceae, &c.). Gamopetalous. *F. splendens* Engelm., the ocotilla or coach-whip, is used in hedge making.

Fourcroya Spreng. = Furcraea Vent.

Fragaria (Tourn.) Linn. Rosaceae (III. 6 b). 8 sp. N. temp. and Andes. *F. vesca* L., the wild strawberry in Brit. Vegetative propagation by runners (p. 153) is well shown in this plant. The flr. is protogynous, and has an epicalyx. The fruit is composed of a number of achenes (the so-called seeds of the strawberry) borne upon a fleshy receptacle. The flr. bends downwards after fertilisation to ripen the fruit. Several sp. are in cultivation for the sake of the fruit. In America the cultivated forms become diœcious or polygamous.

Francoa Cav. Saxifragaceae (II). 2 sp. Chili. See order.

Frangulinae (Warming). The 16th cohort of Choripetalae.

Frankenia Linn. Frankeniaceae. 31 sp. sea-coasts, temp. and sub-trop. *F. laevis* L., sea-heath, in Brit. They are halophytes (see p. 169) with inrolled hairy leaves (cf. Empetrum, &c.).

Frankeniaceae. Dicotyledons (Archichl. Parietales). 4 gen. with 34 sp. of salt-loving plants, trop. and temp. Herbs with jointed stems; leaves opp., inrolled, exstipulate (?). Flrs. in dichasia, ☿, regular. K (4—7), C 4—7, A usually 6 in two whorls, sta. slightly united at base. G usually (3), 1-loc. with parietal placentae, only the lower parts of which bear ovules. Ovules ∞, anatropous, ascending. Style forked. Capsule loculicidal. Mealy endosperm. Embryo straight. *Chief genera:* Frankenia, Niederleinia. The order is closely related to Tamaricaceae and Guttiferae; the agreement with Caryophyllaceae, near to which it is sometimes placed, *e.g.* by Benth.-Hooker, is more in habit than in structure. It is placed in Cistiflorae by Warming.

Fraxinus Tourn. ex Linn. Oleaceae (I. 1). About 40 sp. esp. N. Am., E. As., and Medit. *F. excelsior* L., the common ash, is found in Brit. It has large pinnate leaves, with grooved petioles. Water is said to enter this groove and be absorbed by the leaf; the hollow is usually inhabited by acarids; thus forming a 'domatium' (see p. 115 and Ludwig, *Biologie*, p. 273, &c.). The flrs. appear before the leaves in densely crowded short racemes. Each ☿ flr. consists merely of 2 sta. at right angles to 2 cpls., and is anemophilous; but polygamy is the rule in this sp. and every possible combination of the three types of flr. (☿, ♂, ♀) occurs in various places, sometimes all on one tree, or two on one and one on another, and so on. The fruit is a samara or one-seeded nut with terminal wing aiding in wind distribution. *F. Ornus* L., the 'flowering ash' of S. Eur., has calyx and corolla.

The wood of the ash is valuable on account of its firm elastic nature.

The weeping ash is a variety propagated vegetatively from a single tree which appeared as a sport at Wimpole in Cambridgeshire.

Freesia Klatt. Iridaceae (III). 2 sp. Cape Col. Favourite greenhouse flrs. on account of their delicious scent.

Frenela Mirb. = Callitris Vent.

Freycinetia Gaudich. Pandanaceae. 30 sp. E. Ind., Polynes. Most are climbing shrubs with infl. and flr. like those of Pandanus. The bracts are fleshy and usually brightly coloured. In Java, Burck observed in one sp. pollination effected by a bat (*Pteropus edulis*) which devoured the coloured bracts; in so doing it received pollen upon its head and carried it to the female flr. Fruit a berry, not, as in Pandanus, a drupe.

Freylinia Colla. Scrophulariaceae (II. 6). 2 sp. S. Afr.

Fritillaria (Tourn.) Linn. Liliaceae (V). 40 sp. N. temp. *F. Meleagris* L., snake's head, in Brit. Honey is secreted by large nectaries at the base of the perianth. The bud stands erect and so does the capsule, but the open flr. is pendulous (p. 104).

Froelichia Moench. Amarantaceae (4). 10 sp. temp. Am. Fruit enclosed in the perianth, which forms two wings.

Fuchsia (Plum.) Linn. Onagraceae (VI). 60 sp. Cent. and S. Am., N. Z. Many are cultivated for their flrs. Many sp. show two buds in each leaf-axil, one above the other (p. 42). The flr. is adapted to bees, humming-birds, &c. The berry is edible.

Fuirena Rottb. Cyperaceae (1). 20 sp. trop. and sub-trop.

Fumaria Tourn. ex Linn. Papaveraceae (III). 40 sp. Eur., As., Afr., chiefly Medit. 2 in Brit. (fumitory). Many climb by aid of sensitive petioles (cf. Clematis). The flr. is like that of Corydalis. *F. capreolata* L. var. *pallidiflora* Jord. (Brit.) shows an interesting colour-change in its flr.; before pollination it is white, and then it gradually turns pink or even carmine (cf. Ribes, Diervilla). This has been described as an adaptation to show the more intelligent insects which are the useful (unpollinated) flrs. (see Müller's *Fert. of Flrs.*).

Fumariaceae (Warming) = sub-order III of Papaveraceae.

Funkia Spreng. (*Hosta* Tratt.). Liliaceae (III). 5 sp. Japan, China. Embryos are formed in the seeds by outgrowth of the nucellus-tissue round the embryo-sac (cf. Alchornea). Seeds winged.

Furcraea Vent. Amaryllidaceae (II). 15 sp. trop. Am. Like Agave; the infl. is even more gigantic. *F. gigantea* Vent. yields the fibre known as Mauritius hemp.

Gagea Salisb. Liliaceae (IV). 25 sp. temp. Old World. *G. lutea* Ker-Gawl. in Brit. Flr. protogynous. In the leaf-axils of some sp. are buds which, if fertilisation does not occur, develope into bulbils and drop off (p. 113).

Gahnia Forst. Cyperaceae (II). 32 sp. N.Z., Austr. to China, Polynes.

Gaillardia Fouger. Compositae (VI). 12 sp. Am.

Galactia P. Br. Leguminosae (III. 10). 50 sp. trop. Latex, which is rare in the order, is found in this plant; nothing however seems to be known about the anatomy, &c.

Galactodendron Rchb. = Brosimum Sw.

Galanthus Linn. Amaryllidaceae (I). 6 sp. Eur. *G. nivalis* L., the snowdrop, in Brit. Bulb with 1-flowered scape. Perianth in two whorls. On the inner surface of the inner perianth-leaves are green grooves secreting honey. The bud is erect, but the open flr. is pendulous (p. 104), and adapted to bees. The sta. dehisce by apical slits and lie close against the style. Each has a process going outwards from the anther. The stigma projects beyond the anther-cone and is first touched by an insect. In probing for honey the insect shakes the sta. and receives a shower of pollen (p. 98, and cf. Erica). Autogamy may occur in old flrs. The flr. remains open a long time.

Galax Linn. Diapensiaceae. 1 sp. Virginia, Georgia.

Galeandra Lindl. Orchidaceae (9). 6 sp. trop. Am. Epiphytes.

Galega Tourn. ex Linn. Leguminosae (III. 6). 3 sp. S. Eur., W. As. *G. officinalis* L. is sometimes cultivated as a fodder-plant (goat's rue).

Galeobdolon Adans. = Lamium Tourn.

Galeopsis Linn. Labiatae (VI. 4). 7 sp. N. temp. 3 in Brit., including *G. Tetrahit* L., the hemp-nettle, noteworthy for the swollen upper ends of the internodes; these act as pulvini (p. 49). See Briquet's monograph of G., *Mém. cour. Acad. roy. Belg.* LII. 1893.

Galinsoga Ruiz et Pav. Compositae (V). 4 sp. Mexico to Argentina. *G. parviflora* Cav. is now a common weed on the continent, and is established near Kew.

Galipea Aubl. Rutaceae (V). 6 sp. S. Am.

Galium Linn. Rubiaceae (II. 21). Over 200 sp. mostly temp., 10 in Brit. (bed-straw, &c.). Herbs with whorls of leaves and stipules (see order), and flrs. in dichasial panicles. Flr. small with honey freely exposed (p. 89) on the epigynous disc; in most sp. it is protandrous with ultimate self-pollination. Of the Brit. sp., *G. verum* L. and *G. Aparine* L. (goose-grass or cleavers) are the most frequent. The latter is a feeble hook-climber (p. 172), with small reflexed hooks on the stem. The schizocarp is also provided with hooks.

Galtonia Dcne. Liliaceae (II). 2 sp. S. Afr.

Gamopetalae (Benth.-Hooker) = Sympetalae (p. 134).

Garcinia Linn. Guttiferae (V). 150 sp. trop. Old World. Trees or shrubs with leathery leaves. Sta. free or united into bundles or into a common mass. Fruit a berry. Seed arillate. The resin of *G. Morella* Desr. and other sp., obtained by cutting notches in the stem, forms gamboge. The fruit of many sp. is edible, especially that of *G. Mangostana* L., the mangosteen; it is the aril of the seed of this which is esteemed as a delicacy. Some sp. yield useful timber.

Gardenia Ellis. Rubiacae (I. 8). 60 sp. trop. Old World. They are largely cultivated for their showy strongly-scented flrs. Some sp. have apparently whorls of leaves, 3 in each. This is really a case of condensation of two whorls of 2 into one with extreme anisophylly (p. 47) of one whorl; the fourth leaf is reduced to a minute scale. The stipules of many sp. secrete a resinous fluid.

Garidella Tourn. ex Linn. = Nigella Linn.

Garrya Dougl. ex Lindl. Cornaceae. 8 sp. Calif., Mexico, W. Ind. *G. elliptica* Dougl. is often found in shrubberies. The flrs. are in catkins; 3 flrs. occur in the axil of each bract.

Gasteria Duval. Liliaceae (III). 35 sp. S. Afr. Xerophytes with succulent leaves closely packed together (p. 167), but living in the shade of long grass, &c.

Gastrochilus Wall. Zingiberaceae. 2 sp. Himal., Burmah.

Gastrolobium R. Br. Leguminosae (III. 2). 32 sp. W. Austr.

Gaudichaudia H. B. et K. Malpighiaceae (I). 12 sp. Mexico to Venezuela. Mericarp elevated on carpophore formed from wing of cpl.

Gaultheria Kalm. Ericaceae (II. 5). 100 sp. Am., Japan to Himal.

and Tasmania. *G. procumbens* L. is the winter green, checker-berry or partridge-berry of the U.S. The fruit resembles a berry, but is really a capsule, enclosed in the fleshy calyx but not adhering to it. *G. Shallon* Pursh is the Sallal or shallon of N.W. Am., whose edible fruit deserves to be more widely known and cultivated. An oil is distilled from the plant of some sp.

Gaura Linn. Onagraceae (V). 20 sp. N. Am. The anthers are chambered up by horizontal septa in each loc. (cf. Circaea). Nut.

Gaya H. B. et K. Malvaceae (II). 6 sp. trop. Am.

Gaylussacia H. B. et K. Ericaceae (III. 7). Over 40 sp. Am. (huckleberry). The 5 loc. of the ovary are made into 10 by partitions growing out from the midribs of the cpls., as in Linum.

Gazania Gaertn. Compositae (X). 24 sp. Cape Colony.

Geissoloma Lindl. ex Kunth. *G. marginatum* Kunth, Cape Col., a small xerophytic shrub is the only sp. The genus forms the order Geissolomaceae.

Geissolomaceae. Dicotyledons (Archichl. Thymelaeales). 1 gen. Geissoloma. A monotypic order united to Penaeaceae by Benth.-Hooker.

Gelsemium Juss. Loganiaceae. 2 sp. N. Am., As. *G. sempervirens* Ait. is known as Carolina jasmine. The peduncle bears a large number of bracteoles.

Genista Linn. Leguminosae (III. 3). 80 sp. Eur., N. Afr., W. As.; 3 in Brit. *G. anglica* L. (needle-gorse or petty whin) has large thorns (branches). The flr. has an explosive mechanism, typical of many of the order (see Leguminosae). In *G. tinctoria* L., the dyer's greenweed (see Müller's *Fert. of Flrs.* p. 189), there is no honey; the style and tube of sta. are enclosed in the keel, which is united along the top seam as well as the bottom. The sta. shed their pollen almost in the apex of the keel, but not so near it as to pollinate the stigma. When the flr. opens there is a tension of the sta.-tube on the lower side tending to bend it upwards; this is resisted by an opposite one in the keel and wings, but if an insect alight on the wings and press them down, the upper seam of the keel gives way and an explosion follows. In it the style flies out, striking the under side of the insect, thus probably becoming cross-pollinated, and is followed by a shower of pollen which gives the insect a fresh coating to take to another flr.

A yellow dye is obtained from the flrs. of this sp., which when mixed with woad gives a fine green (Kendal green).

Gentiana Tourn. ex Linn. Gentianaceae (I. 3). 300 sp. chiefly alpine, Eur., As., N. Am., Andes, Austr., N.Z.; 5 sp. of gentian in Brit. Most are alpine plants of tufted growth (p. 181). The flrs. are of much interest (see *Nat. Pfl.*, Müller's *Fert. of Flrs.*, *Alpenblumen*, &c.). The genus divides into two subgenera, according to the position of the nectaries—in *Eugentiana* on the base of the ovary, in *Gentianella* on the base of the corolla. In each section we find an ascending series of flrs., adapted to higher and higher types of insects. The more common sp. may be thus grouped (biologically and to a large extent morphologically):

Ancestral type.

G. lutea L.	Eugentiana	Gentianella.
	↓	↓
	§ *Coelanthe* (humble-bee flrs.).	§ *Crossopetalum* (humble-bee flrs.).
	↓	↓
	§ *Cyclostigma* (Lepidoptera flrs.).	§ *Endotricha* (Lepid. and humble-bee flrs.).

In *G. lutea* L. the honey is freely exposed (p. 89), the corolla being rotate; the visitors are mostly short-tongued. The colour too is yellow (p. 100) and the flr. is homogamous. To § *Coelanthe* belong *G. purpurea* L., *G. Pneumonanthe* L., &c. The latter sp. (Brit.) has a blue corolla with a long tube, is protandrous and visited by humble-bees (class H, p. 92). To § *Cyclostigma* belong *G. bavarica* L., *G. verna* L., *G. nivalis* L., &c.; *G. verna* (Brit.) resembles *G. Pneumonanthe* but has a still longer and narrower tube and is visited by Lepidoptera. Turning to the other division, we find similar phenomena. *G. ciliata* L. (§ *Crossopetalum*) is a protandrous bee-flr., *G. Amarella* L. (Brit.; § *Endotricha*) a homogamous bee- and Lepidoptera-flr. *G. campestris* L. (Brit.) is similar. This sketch of the probable course of evolution of the gentians is of course hypothetical, but not more so than most hypotheses of the evolution of existing forms of life. It is a good illustration of the general argument of the Theory of Flowers set forth on pp. 87—94, which should be carefully read in connection with this article.

The gentians form one of the most striking features of the flora of the Alps, occurring in large masses and with very conspicuous flrs.; *G. acaulis* L. is the most beautiful. In the Brit. Mts. they are rare. The root of *G. lutea* furnishes a tonic.

Gentianaceae. Dicotyledons (Sympet. Contortae). 64 gen. with 750 sp. The order has representatives in every part of the globe and in a great variety of situations—arctic and alpine plants, halophytes, saprophytes (Voyria, &c.), marsh plants (Menyanthes, &c.), water plants (Limnanthemum), &c. They are mostly herbaceous plants (often perennial), but a few shrubs occur. The perennial herbs have usually a rhizome. Leaves opp., exstip., usually entire. The infl. is usually a dichasial cyme like that of Caryophyllaceae; as in that order, the lateral branches often become monochasial. Other cymose infls. also occur. Bracts and bracteoles present or not. Flrs. regular, ☿, 4—5-merous (rarely more). K usually (5), imbricate; C (5), bell- or funnel-shaped, or sometimes salver-shaped, convolute (exc. Bartonia, Obolaria, &c., and sub-order II). Sta. as many as petals, alternate with them, epipetalous; anthers various, usually introrse. Gynœceum with a glandular disc at the base, of (2) cpls., syncarpous, superior, placed in the antero-posterior plane. Placentae usually parietal, but they commonly project far into the cavity and spread out at their ends; occasionally the ovary is 2-loc. with axile placentation. Ovules usually ∞, anatropous. Style simple; stigma simple or 2-lobed. Fruit usually a septicidal capsule with ∞ seeds, rarely a berry (Chironia, &c.). Seeds small. Embryo small, in abundant endosperm.

The flowers of G. are insect-fertilised. The genus Gentiana has been very fully studied; see also Menyanthes (dimorphic).

Classification and chief genera: The grouping of the order by Gilg in *Nat. Pfl.* is largely based on the characters of the pollen, and is thus of little use for the purposes of this book; Engler classifies the G. thus.

I. *Gentianoideae* (leaves opp.: corolla convol. or imbric.):
  1. *Exaceae* (ov. 2-loc,): Exacum.
  2. *Chironieae* (ov. 1-loc. with projecting plac.): Erythraea, Chlora.
  3. *Swertieae* (do. plac. not projecting): Gentiana, Swertia.

II. *Menyanthoideae* (leaves alt.; corolla induplicate-valvate): Menyanthes, Limnanthemum.

[Placed in Gentianales by Benth.-Hooker, in Contortae by Warming.]

Gentianales (Benth.-Hooker). The 7th cohort of Gamopetalae (p. 135).

Geonoma Willd. Palmae (IV. 6). 80 sp. trop. Am.

Geraniaceae. Dicotyledons (Archichl. Geraniales). 11 gen. with 430 sp., cosmop. Mostly herbs, often hairy; Sarcocaulon has a fleshy habit. Flr. usually regular, ☿, 5-merous. K 5, imbricate with valvate tips, persistent; C 5, imbricate or convolute; Sta. as many or 2 or 3 times as many as petals, united at base, obdiplostemonous when more than one whorl. Cpls. (5) or (2—3) or (3—5), with 1—2 or 2—∞ ovules in each on axile placentae. Ovules usually pendulous, with ventral raphe and micropyle facing upwards; style long with 5 stigmas. The flrs. are usually protandrous. Fruit usually a schizocarp, the cpls. splitting off from a central beak (the persistent style). Each takes with it a strip of the tissue of the style, forming an *awn*, which is usually hygroscopic (see Geranium, Erodium). Embryo straight or folded, in endosperm. *Chief genera:* Geranium, Erodium, Pelargonium, Sarcocaulon. Benth.-Hooker unite to G. the Oxalidaceae, Limnanthaceae, Tropaeolaceae and Balsaminaceae, but there is good reason for separating these from G., especially the last named. They place G. in Geraniales; Warming places the order, defined as by Engler, in Gruinales.

Geraniales. The 15th cohort (Engler) of Dicotyledons (Archichl.).

See p. 128. The 7th cohort (Benth.-Hooker) of Polypetalae (p. 133).

Geranium (Tourn.) Linn. Geraniaceae. 160 sp. temp. (12 in Brit. of which *G. pratense* L., meadow cranesbill, and *G. Robertianum* L., herb Robert, are the most noteworthy). The infl. is cymose, either dichasial with a cincinnus-tendency (by preference of the β-bracteole), or a cincinnus alone, which is straightened out into a sympodium. The nectaries are at the base of the sta. These stand at first round the undeveloped style; after dehiscence they move away, and finally the stigmas open. The fruit explodes, the awn twisting up so that the cpls. are carried upwards and outwards. In many sp. they open at the same time and the seeds are shot out. The G. of greenhouses is really a Pelargonium.

Gerardia Linn. Scrophulariaceae (III. 11). 30 sp. Am.

Gerbera Gronov. Compositae (XII). 30 sp. Afr., As.

Gesneria Linn. Gesneriaceae (II). About 60 sp. trop. Am.

Gesneriaceae. Dicotyledons (Sympet. Tubiflorae). About 85 gen. with 700 sp. trop. and sub-trop. Most are herbaceous or slightly woody plants; shrubs and trees are rare. Leaves usually opp., rarely whorled or alt., entire or toothed, never divided, exstip. Some are root-climbers, and amongst these are a few epiphytes, *e.g.* Aeschynanthus, usually with fleshy water-storing leaves. Many are tuberous plants, *e.g.* the familiar Sinningia (Gloxinia) of our greenhouses. A number of sp. reproduce vegetatively by means of curious runners or suckers, covered with scale-leaves; these are usually formed below ground; instances are Naegelia, Isoloma, &c. A very peculiar morphology and life-history is found in Streptocarpus (*q.v.*).

Flrs. solitary or in cymose infls. of various types, ☿, usually markedly zygomorphic. K (5), usually with very short teeth, generally valvate; C (5), often 2-lipped; imbricate (in Ramondia, &c. it is nearly rotate and regular); A usually 4, didynamous, sometimes 2, sometimes 5 (Ramondia, &c.), alt. with corolla-lobes; staminodes are often found. At the base of the flower-tube is a disc, whose various shapes form important marks in distinguishing the genera; it may be ring-shaped (thin or thick), 5-angled, 5-lobed, or reduced to 5 or fewer glands. The ovary may be superior, or more or less inferior (see below); it is always of (2) cpls., 1-loc. with parietal placentae which sometimes project inwards so far that it becomes imperfectly 2-loc. Ovules ∞, anatropous. Style simple; stigma often bilobed. Fruit usually a capsule, splitting loculicidally into 2 valves, each of which may again split into 2; sometimes (Ramondia) the capsule is septicidal, or opens only at the tip, or the fruit may be more or less fleshy or berry-like. Seeds small and numerous, with endosperm (§ II) or without (most of § I). Embryo straight.

The flrs. are mostly protandrous; their large size and bright colours indicate insect-fertilisation, but nothing is known about the details. Saintpaulia (*q.v.*) and others exhibit two types of floral symmetry on the same plant.

None of the G. are economic plants; many are hothouse favourites.
Classification and chief genera (after Fritsch):

"The relationships to allied orders, especially Scrophulariaceae, Orobanchaceae and Bignoniaceae, are so close that it is almost impossible to draw the dividing lines. The B. are most sharply marked off by the structure and formation of their fruit and seed, and often by their divided leaves. The O. might very well be placed in G. as a parasitic sub-order. The placentation and structure of the ovary is the chief mark of distinction between the G., O., and S."

I. *CYRTANDROIDEAE* (ovary free, superior): Ramondia, Saintpaulia, Didymocarpus, Streptocarpus, Aeschynanthus, Besleria, Cyrtandra, Columnea.

II. *GESNERIOIDEAE* (ovary more or less inferior): Achimenes, Isoloma, Gesneria.

[Placed in Personales by Benth.-Hooker, in Personatae by Warming.]

Gethyllis Plum. ex Linn. Amaryllidaceae (I). 9 sp. Cape Col.

Geum Linn. Rosaceae (III. 6 c). 36 sp. N. and S. temp., arctic. *G. rivale* L., the water avens, with a thick rhizome and large protogynous flrs. is frequent, and *G. urbanum* L., wood avens, with smaller nearly homogamous flrs., abundant in Brit. Both sp. with many others of the genus, have a hook on each achene of the fruit to aid in distribution. If the style be examined in a newly opened flr. it will be found to have a Z-like kink in it. The lower half of this after fertilisation gets larger and more woody, while the upper half finally drops off.

Gigantochloa Kurz. Gramineae (XIII). 5 sp. Indo-mal. Giant bamboos.

Gilia Ruiz. et Pav. Polemoniaceae. 90 sp. temp. and subtrop. Am.

Gillenia Moench. Rosaceae (I. 1). 2 sp. N. Am.

Ginkgo Linn. Coniferae (Taxaceae of Eichler, but better placed in a separate order Ginkgoaceae; see C. for genus characters, and cf. *Ann. of Bot.* 1900, p. 108). 1 sp. *G. biloba* L. (*Salisburia adiantifolia* Sm.), China, Japan, the maiden-hair tree. Its leaves resemble those of the maiden-hair fern. In former ages G. was widely spread. Sp. occur in the Tertiary strata of England. There are 'long' and 'short' shoots, the latter bearing a few scale leaves and several of the curious green leaves, with their *forked* venation (cf. Cycads and Ferns). Leaves deciduous; the short shoot bears a new set each year. Flrs. diœcious, in the axils of the uppermost scales or lowest green leaves of a short shoot (so that their position differs from the usual one in Conifers with long and short shoots). The male has the form of a loose catkin of sta. The female is long-stalked, with two ovules borne on rudimentary cpls. (see order). Seed usually one only, with fleshy aril. The seed is 'ripe' and falls from the tree before fertilisation of the ovule takes place; this process, and the embryo-development occur on the ground during the winter. The seed is edible, and yields an oil. The timber is useful.

Girardinia Gaudich. Urticaceae (I). 6 sp. trop. As., Afr.

Githago Adans. = Lychnis Linn.

Gladiolus (Tourn.) Linn. Iridaceae (III). 90 sp. S. Afr., trop. Afr., Eur., As. Favourites in horticulture. Flrs. in many sp. protandrous. Leaves isobilateral.

Glaucium Tourn. ex Hall. Papaveraceae (II). 12 sp. Eur., As. *G. flavum* Crantz, yellow horned-poppy, on sea-shores in Brit. (p. 186).

Glaux (Tourn.) Linn. Primulaceae (III). *G. maritima* L., sea milk-wort, the only sp., N. temp. maritime (incl. Brit.). A halophyte (p. 169) with fleshy leaves. The seeding plant dies after producing in the axil of one cotyledon a hibernating shoot, with a root of its own. From this new plant fresh plants arise vegetatively, the process being repeated for several years before flowering. Runners with scale leaves in whose axils renewal-shoots form, appear before the flowering period (see Pax in *Nat. Pfl.* for details). The flr. has no corolla, but a coloured calyx.

Glaziovia Benth. et Hook. f. Bignoniaceae (I). 1 sp. Brazil. The tendrils have flat discs at the tip, which adhere like those of the Virginian creeper (Vitis, q.v.).

Glechoma Linn. = Nepeta Linn.

Gleditschia Clayton. Leguminosae (II. 7). 11 sp. sub-trop. Am., As. The stems are usually provided with stout branched thorns (stem structures, arising in leaf axils). The thorn comes from the uppermost of a whole series of buds arranged one above the other in the leaf axil. No winter buds are formed, and the young apex of each twig dies off in winter, the next year's growth starting laterally. Some sp. are used for hedges; some yield useful timber.

Gleichenia Sm. Gleicheniaceae. 30 sp. trop. and S. Hemisph. They have creeping rhizomes; the leaves are repeatedly branched in an apparently dichotomous way.

Gleicheniaceae. Filicineae Leptosporangiatae (Homosporous). 2 genera with 40 sp., trop., sub-trop. and S. temp. They are small ferns with creeping rhizomes and dichotomously branched leaves. Sorus of 2—8 sessile sporangia, without indusium, with a complete transverse annulus, and dehiscing longitudinally. *Chief genus:* Gleichenia.

Globba Linn. Zingiberaceae. 24 sp. E. Ind. and Malaya. The flr. is rather complex. There is a short calyx; above this is the corolla tube, from the end of which spring 3 petals, a large labellum and 2 staminodes, also the slightly petaloid fertile sta., projecting beyond which is the style. The ovary is 1-loc. with parietal placentae. The lower cymes are usually replaced by bulbils; the mass of one of these consists (see fig. in *Nat. Pfl.*) of a root, springing laterally from the axis.

Globularia Tourn. ex Linn. Globulariaceae. 17 sp. Medit., Eur.

G. vulgaris L., &c., occur in the Alps; "the only instance in the German and Swiss flora of a blue colour produced by the selective agency of Lepidoptera" (Müller).

Globulariaceae. Dicotyledons (Sympet. Tubiflorae). 3 gen. with 20 sp., Eur., Medit., Afr. Herbs or shrubs with alt., exstip., simple leaves and heads or spikes of flrs. with or without involucres of bracts. Flr. ☿. K (5), persistent; C (5), median-zygomorphic; the upper lip of 2 petals is shorter than the 3-petalled lower lip; A 4, didynamous, epipetalous. Ovary superior, 1-loc., with 1 pendulous anatropous ovule. Fruit a one-seeded nut, free in base of calyx. Embryo straight, in endosperm. *Chief genus:* Globularia. Benth.-Hooker unite the order to Selagineae (see Scrophulariaceae); Warming places it in Nuculiferae.

Glochidion Forst. Euphorbiaceae (A. I. 1). 135 sp. trop. As., Polynes.

Gloriosa Linn. Liliaceae (I). 3 sp. trop. As., Afr. Favourite greenhouse plants. They climb by aid of the leaves, whose tips twine like tendrils (p. 172). Flr. pendulous, with the sta. and style projecting horizontally.

Glossocomia Rchb. = Codonopsis Wall.

Glossodia R. Br. Orchidaceae (4). 5 sp. Austr. At the base of the labellum are two more or less joined projections, which are perhaps equivalent to the divided staminode of the median sta. of the inner whorl (see order).

Glossostigma Wight et Arn. Scrophulariaceae (II. 8). 3 sp. Austr., N. Z., trop. As., Afr.

Gloxinia L'Hérit. Gesneriaceae (II). 6 sp. trop. Am. For *G. speciosa* Lodd., &c., so often cultivated in hot-houses, see Sinningia.

Glumaceae (Benth.-Hooker). The 7th series of Monocotyledons (p. 136).

Glumiflorae. The 3rd cohort (Engler) or 2nd (Warming) of Monocotyledons (pp. 126, 137).

Glyceria R. Br. Gramineae (X). 16 sp. cosmop., esp. N. Am. 2 in Brit. Pasture grasses in wet meadows.

Glycine Linn. (incl. *Soja* Moench.). Leguminosae (III. 10). 16 sp. trop. Afr., As., Austr. *G. Soja* Sieb. et Zucc. and *G. hispida* Maxim. yield Soja beans, eaten in Japan, &c. and used as green fodder. An oil is obtained from the seeds.

Glycosmis Correa. Rutaceae (X). 6 sp. trop. Afr., Ind., Austr. Fruit edible.

Glycyrrhiza Tourn. ex Linn. Leguminosae (III. 6). 12 sp. temp. and sub-trop. An extract of the rhizome of *G. glabra* L. forms Spanish liquorice.

Glyptostrobus Endl. Coniferae (Arauc. 1 c.; see C. for genus characters). 2 sp. China, *G. pendulus* Endl. and *G. heterophyllus* Endl. United to Taxodium by Benth.-Hooker.

Gnaphalium Linn. Compositae (IV). 120 sp. cosmop.; 4 in Brit.

(cudweed). *G. supinum* L., found in alpine regions in Scotland, is a tufted hairy xerophyte (p. 181). [For *G. dioicum* L. see Antennaria, for *G. Leontopodium* L. see Leontopodium.]

Gnetaceae. The only order in the third and highest class of the Gymnosperms, comprising 3 very distinct genera with about 40 sp. trop. and sub-trop. These agree in very few points, and ought perhaps to form separate natural orders. They are distinguished from the Coniferae by the absence of resin, by the presence of vessels in the secondary wood, and by the occurrence of a perianth. For details of structure reference must be made to the genera; see also Gymnospermae.

Genera: Ephedra, Gnetum, Welwitschia.

Gnetum Linn. Gnetaceae. 15 sp. trop. Most are climbing shrubs, a few erect shrubs or small trees. Leaves decussate, exstip., simple, evergreen, leathery. Flrs. diœcious, in spikes which are frequently grouped into more complex infls. The spike bears decussate bracts, in whose axils are condensed partial infls. of a large number of flrs. (cf. Labiatae), about 3—8 in the ♀, but more (up to 40) in the ♂. These flrs. form whorls round the stem, and are intermingled with numerous hair-structures. At the top of the ♂ infl. are sterile ♀ flrs. The ♂ has a tubular (2-leafed) perianth, from the top of which the axis projects; at the tip of the axis, right and left, are two sessile 1-loc. anthers. The ♀ has a tubular perianth like that of Ephedra, surrounding a single orthotropous erect ovule with two integuments; the inner of these projects at the apex of the flr. After fertilisation the perianth becomes fleshy, the outer integument woody, forming a drupe-like fruit. *G. Gnemon* L. (Malay) and other sp. are cultivated for the edible fruit. [See Gymnospermae, and Karsten in Cohn's *Beiträge* VI., *Bot. Zeit.* 1892, *Ann. Buitenz.* XI. &c.]

Gnidia Linn. Thymelaeaceae. 90 sp. Afr., Madag., E. Ind.

Godetia Spach = Oenothera Linn.

Goethea Nees. Malvaceae (III). 2 sp. Brazil. Closely allied to Pavonia, some sp. of which are often placed in G. There are several buds in each leaf-axil, some of which give rise years later to flrs., borne on the old wood (p. 156). The epicalyx is brightly coloured. The corolla does not spread out, but the styles first emerge and afterwards the sta. (the reverse of the usual behaviour in Malvaceae). Honey is secreted at the base of the calyx. The styles are twice as numerous as the cpls. (see Pavonia).

Goldfussia Nees = Strobilanthes Blume.

Gomphia Schreb. (*Ouratea* Aubl.). Ochnaceae. 120 sp. trop. Am., As., Afr. Like Ochna, but sta. 10 only.

Gomphocarpus R. Br. Asclepiadaceae (II. 2). 100 sp. trop. and South Afr., and S. Am. *G. fruticosus* R. Br. is wild on the shores of nearly all trop. lands, having spread from Afr.

Gompholobium Sm. Leguminosae (III. 2). 24 sp. Austr.

Gomphrena Linn. Amarantaceae (4). 90 sp. S. Am., Austr. Herbs with cymose heads of flrs. Flr. ☿ with 5 hairy perianth-leaves and 5 sta. united into a tube.

Gonatanthus Klotzsch. Araceae (VI). 2 sp. Himal.

Gongora Ruiz et Pav. (*Acropera* Lindl.). Orchidaceae (19). 20 sp. trop. Am. Epiphytes with hanging flrs. whose ovary is so bent that the labellum comes to stand above the column. The sepals and petals spring from the column (an argument for its axial nature). See Darwin, *Orchids*, p. 166.

Goniolimon Boiss. = Statice Tourn.

Gonolobus Michx. Asclepiadaceae (II. 5). 70 sp. Am.

Goodenia Sm. Goodeniaceae (I). 70 sp. Austr.

Goodeniaceae. Dicotyledons (Sympet. Campanulatae). 12 gen. with 210 sp., chiefly Austr., a few N.Z., Polynes., and trop. coasts. Herbs and shrubs with alt. exstip. leaves and no latex. Flrs. ☿, zygomorphic, solitary in the leaf-axils or in cymes, racemes, or spikes. K usually 5, small; C (5); A 5, alt. with the petals, epipetalous or not, with introrse sometimes syngenesious anthers; G (2), inferior or semi-inferior, rarely superior, 1- or 2-loc.; style simple with 'pollen-cup' close under the stigma. Into this the pollen is shed in the bud; "the cup then closes up, leaving only a narrow opening for the most part covered by hairs. At the same time the style bends down to stand in the mouth of the almost horizontal flr., so that insect-visitors come in contact with the hairs and dust themselves with a little of the powdery pollen. As the stigmatic lobes grow up in the cup they keep forcing fresh pollen into the narrow slit, and finally emerge by it themselves and then receive the pollen of younger flrs. from insect-visitors" (Müller). The mechanism should be carefully compared with that of Campanulaceae and Compositae. Ovules usually ascending, anatropous. Fruit usually capsular, sometimes a nut or drupe. Embryo straight, in fleshy endosperm.

Classification and chief genera (after Schönland): The G. are very closely allied to Campanulaceae, differing chiefly in the absence of latex and the presence of the pollen-cup. They resemble Gentianaceae in a few points.

I. *GOODENIOIDEAE* (flrs. rarely in heads; corolla folded in bud; ovary inf. or ½-inf., with usually 2 or more ovules; endosperm): Velleia, Goodenia, Leschenaultia, Selliera, Scaevola, Dampiera.

II. *BRUNONIOIDEAE* (flrs. in heads; corolla valvate; ovary sup., 1-ovuled; no endosperm): Brunonia (only genus).

[Placed in Campanales by Benth.-Hooker, in Campanulinae by Warming.]

Goodenovieae (Benth.-Hooker) = Goodeniaceae.

Goodia Salisb. Leguminosae (III. 3). 2 sp. S. Austr.

Goodyera R. Br. Orchidaceae (4). 25 sp. N. temp., trop. As., New

Caled., Mascarenes; *G. repens* R. Br. in Brit. Flr. as in Epipactis (Darwin, *Orchids*, p. 103).

Gordonia Ellis. Theaceae. 16 sp. Indo-mal., China, N. Am. Seeds winged. The bark of *G. Lasianthus* Linn. (loblolly-bay, south U.S.) is employed for tanning. Sta. opp. to petals.

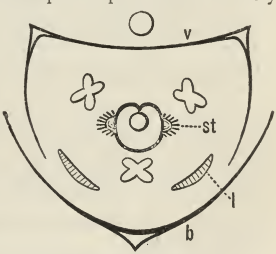
Gossypium Linn. Malvaceae (IV). 9 sp. trop. and sub-trop. Epicalyx of 3 leaves. G (5). Loculicidal capsule. The seeds are covered with long hairs for wind-dispersal; these hairs form the material known as cotton. The cultivated forms are apparently reducible to 3 sp., *G. barbadense* L. (trop. Am.), *G. arboreum* L. (Old World), and *G. herbaceum* L. (ditto). The cotton separates easily from the seed in the first sp., which is the Sea Island cotton of the U.S.; in Egypt, India, &c. the other sp. are most used. From the seeds an oil is obtained by crushing (cotton-seed oil), and the oil-cake left behind is largely used for feeding cattle, &c. The flrs. are visited by bees and (in Am.) by humming-birds. For details see Mueller's *Select Extratrop. Plants*.

Gouania Jacq. Rhamnaceae. 40 sp. trop. Some have watch-spring tendrils (p. 172). The stalks of some sp. contain saponin.

Gramineae. Monocotyledons (Glumiflorae). One of the largest orders of flowering plants, with about 310 gen. and 3600 sp. found in all regions of the globe. In the temp. zones especially they are a most important feature in the vegetation, forming prairies, steppes, &c. (p. 188). Most grasses are herbaceous, but a few, chiefly the bamboos, reach a large size, even as much as 100 ft. in height. Many are annual, but many are perennial; the latter commonly branch largely from their lower nodes and thus often give rise to a tufted habit (as seen in many common sp.); many sp. possess rhizomes. The stem has well-marked nodes, composed chiefly of softer tissues. If a stem be bent downwards (as occurs when wheat is 'laid') these nodes recommence growth, growing more rapidly upon the lower side, so that the stem is once more brought to the vertical position. The stem is usually hollow (exc. Zea, Saccharum, &c.) and circular in section. The leaves are alt., and with few exceptions, in 2-ranked phyllotaxy (p. 46); they have a sheathing base, the edges of the sheath overlapping one another upon the side of the stem opp. to the blade (cf. Cyperaceae); there is no petiole (exc. in a few bamboos, &c.), and at the junction of blade and sheath there is a little membranous outgrowth, termed the *ligule*, upon the upper side of the leaf. The blade is usually linear. Many xerophytic grasses have grooves along the upper side of the leaf, with the stomata at the bases of the grooves (p. 165); in most of these cases the leaf rolls up upwards in dry air, so as to enclose the stomata completely and check transpiration; the lower surface which thus becomes the outer one, is covered with thick-walled cells and has no stomata. When the air again becomes moist the leaf unrolls.

The infl. is rather complex; the unit of infl. is not the individual flr. but a *spikelet*, or small spike of flrs. These are well seen in oats, where the spikelets are arranged in a panicle; in wheat the spikelets are sessile upon the main axis, forming a compound spike, usually termed simply a spike (p. 63); this is more clearly seen in rye-grass. Each of these spikelets consists of one or more (usually not more than 5) flrs. one above the other on opp. sides of a very short axis, the whole enclosed in one or two or more larger leaves at the base of the axis, the *glumes*. The first diagram gives a rough representation of the construction of a spikelet. The central line represents the axis (supposed elongated), which bears at the base usually two leaves with nothing in their axils; these are the glumes. Above them stand one or more leaves, the *inferior paleae*, in whose axils occur flrs. (sometimes aborted). The flr. is very reduced (or primitive, see p. 75). Upon its axis, opposite to the inferior palea, stands another leaf, the *superior palea*. Between the paleae the flr. itself is enclosed. The superior palea, being upon the same axis as the flr., is evidently its bracteole. Owing to the shortness of the floral axis, it appears to be in the axil of the inferior palea, or even upon the main axis of the spikelet. Above the superior palea are two very small scales, the *lodicules*; they are opposite to the superior palea (l in fig.) and insignificant in size. They are sometimes supposed to represent two of the three leaves of a reduced perianth, but it seems more probable that they really represent a second bracteole and that the flr. is perfectly naked. The flr. itself has usually 3 sta. with long filaments and versatile anthers, and 1 cpl. forming a 1-loc. ovary, with 1 basal erect anatropous ovule, and 1 or more (usually 2) stigmas, which are much branched. This ovary has sometimes been regarded as formed of more than 1 cpl., but the suture of the posterior side of the ovary (cf. Prunus) seems to point clearly to its being of 1 cpl. only. The two stigmas may then be regarded as developments of the lateral parts of the cpl. whilst the central part (which usually forms the stigma) remains undeveloped; this also is the explanation of the two lodicules placed right and left of the proper position for an upper bracteole.

inf. palea -|
|- inf. palea
inf. palea -|
|- inf. palea
inner glume -|
|- outer glume



Floral diagram of a grass (after Eichler). b, inferior palea; v, superior palea; l, lodicule; st., stigma.

All the flrs. in the spikelet are enclosed as a rule within the glumes until ready to open. Then the glumes separate, and the hygroscopic lodicules force apart the paleae of the individual flrs. Most sp. in Eur. are protogynous; the sta. grow very rapidly in warm weather and suspend the anthers clear of the paleae so that the loose powdery pollen is easily blown away and may be caught by the large stigma of another flr. (p. 86).

The fruit is a caryopsis (p. 108), *i.e.* an achene whose pericarp is completely united to the seed-coat. Its construction can be well seen in maize (or wheat); at the broad end is the scar of the style, and on the under side at the pointed end is the embryo; on the upper side is the *hilum* or point where the ovule was attached to the wall of the cpl. (the form of this scar is important in classification); the bulk of the seed consists of flowery endosperm. The embryo is straight, with its one cotyledon (*scutellum*) completely enwrapping the radicle and plumule (this can be easily made out by dissecting soaked material). The radicle is towards the lower end of the fruit. In germination the cotyledon remains within the seed and extracts the nourishment from the endosperm; afterwards it merely withers away (p. 112). Most grass fruits are sufficiently light to be dispersed by wind, especially as the paleae often remain attached to them and become dry and chaffy. Others have hooks or other adaptations for dispersal. Of special interest is the self-burying arrangement in Stipa (*q.v.*), effected by aid of the *awn* (this term is applied to any long thread-like outgrowth of glume or palea). Many grasses, *e.g.* sp. of Poa and Festuca, are *viviparous*, especially on mountains. The spikelets are replaced by leafy shoots with adventitious roots at their bases. These drop off and grow upon the soil (cf. Agave, Allium, &c.).

From the economic point of view the G. are only rivalled in importance, if at all, by the Palmae and Leguminosae. The cereal grasses, *e.g.* Oryza, Triticum, Zea, Avena, Hordeum, &c. (see p. 204), afford food to a large proportion of the earth's inhabitants. Many grasses are valuable as fodder for domestic animals (see p. 203), or for hay. The bamboos supply many of the wants of the natives of trop. countries.

Classification and chief genera (after Hackel): the G. show near relationship only to Cyperaceae and perhaps Juncaceae, and are easily distinguished from these either by their vegetative or floral characters.

A. Spikelets 1-flowered without elongation of the axis beyond the flr., or 2-flowered with the lower flr. imperfect; without measurable internode between the individual glumes or paleae, and when ripe falling off from the stalk as a whole or together with certain parts of the axis of the spike.

a. Hilum point like; spikelets not compressed laterally, but usually dorsally compressed or cylindrical.

I. *Maydeae* (inf. palea and, when present, sup. palea thin and membranous; glumes firm, even leathery or cartilaginous, the lowest one the largest and overlapping the rest; spikelets usually in racemes or spikes which become jointed when ripe; ♂ and ♀ spikelets in separate infls. or in separate parts of the same infl.): Euchlaena, Zea, Coix.

II. *Andropogoneae* (as I, but spikelets ☿, or ♂ and ♀ side by side in the same infl.): Saccharum, Andropogon, Sorghum.

III. *Zoysieae* (paleae membranous; glumes herbaceous, papery or leathery, the lowest usually the largest; spikelets falling singly or in groups from an unjointed spike-axis): Zoysia.

IV. *Tristegineae* (paleae membranous; glumes herbaceous or firm and papery, the lowest smaller or narrower than the rest; spikelets falling singly from the twigs of a panicle): Arundinella.

V. *Paniceae* (paleae usually cartilaginous, leathery or papery; glumes more delicate, usually herbaceous, the lowest usually smaller; spikelets falling singly from the twigs of a panicle or unjointed spike-axis): Paspalum, †Panicum, †Setaria, Cenchrus, Pennisetum, Spinifex.

b. Hilum linear; spikelets laterally compressed.

VI. *Oryzeae:* Zizania, Oryza, Lygeum, †Leersia.

B. Spikelets 1—many-flowered; when 1-flowered often with a prolongation of the axis above the flr., their stalks usually jointed above the glumes, so that they fall off leaving these on the axis; when 2- or more-flowered, always with distinct internodes between the flrs.

a. Stem herbaceous, annual. No petiole, or joint between blade and sheath.

VII. *Phalarideae* (spikelets in panicles, spikelike panicles or racemes, on distinct stalks—sometimes very short, not set in notches on the main axis; 1-flowered, with 4 glumes and 1-nerved sup. palea): †Phalaris, †Anthoxanthum, †Hierochloe.

VIII. *Agrostideae* (as VII, but spikelets with two or no glumes and 2-nerved sup. palea): Aristida, Stipa, †Milium, †Phleum, †Alopecurus, †Mibora, Sporobolus, †Polypogon, †Agrostis, †Gastridium, †Calamagrostis, †Ammophila, †Apera, †Lagurus.

IX. *Aveneae* (infl. as VII, but spikelets 2—many-flowered; inf. paleae usually shorter than glumes, with twisted awn upon the dorsal side, more rarely with no awn or with an awn upon the tip as X, but then always with 2 almost opp. flrs. and no prolongation of the axis beyond them): †Holcus, †Aira, †Corynephorus, †Deschampsia, †Trisetum, †Avena, †Arrhenatherum, Danthonia.

X. *Festuceae* (as IX, but inf. palea usually longer than glume, without awn or with untwisted awn at tip): †Sesleria, Gynerium, Arundo, †Phragmites, †Triodia, †Molinia, Eragrostis, †Koeleria, †Catabrosa, †Melica, †Briza, †Dactylis, †Cynosurus, †Poa, †Glyceria, †Festuca, †Bromus, †Brachypodium.

XI. *Chlorideae* (spikelets in 2 rows approximated to one another, forming a one-sided spike or raceme with unjointed axis): †Cynodon, †Spartina, Chloris, Bouteloua, Eleusine.

XII. *Hordeeae* (spikelets in 2, or rarely more, opp. rows, forming a symmetrical, rarely one-sided, spike): †Nardus, †Lolium, †Lepturus, †Agropyrum, Secale, Triticum, †Hordeum, †Elymus.

b. Stem woody, at least below; leaf often petiolate, finally separating from its sheath by a joint.

XIII. *Bambuseae*: Arundinaria, Bambusa, Dendrocalamus.

The genera marked with a dagger (†) are those of the British flora. Many are rare and unimportant. Space will not permit of giving a key to the genera; the student should work through the commoner ones with a flora, or Hutchinson's *British Grasses*. [G. are placed in Glumaceae by Benth.-Hooker, in Glumiflorae by Eichler and Warming.]

Grammanthes DC. Crassulaceae. 1 sp. Cape Col.

Gratiola (Rupp.) Linn. Scrophulariaceae (II. 8). 24 sp. cosmop. Sta. 2. The dried plant of *G. officinalis* L. was formerly officinal.

Grevillea R. Br. Proteaceae (II). 160 sp. Austr. Trees and shrubs with leaves of various kinds and racemose infls., with 2 flrs. in each axil. The style projects from the bud as a long loop, the stigma being held by the perianth until the pollen is shed upon it. Then the style straightens out, and the pollen may be removed by visiting insects, the stigma not being yet receptive; presently the female stage supervenes, and if all the pollen has not been removed, autogamy may occur. Some sp. yield useful timber.

Grewia Linn. Tiliaceae. 90 sp. As., Afr., Austr., esp. trop.

Grindelia Willd. Compositae (III). 25 sp. Am.

Griselinia Forst. f. Cornaceae. 2 sp. N. Z.

Griselinia Scop. = Pterocarpus Linn.

Gronovia Houst. ex Linn. Loasaceae (I). 2 sp. trop. Am. Sta. 5, and no staminodes. Cpl. 1.

Grossularia Tourn. ex Adans. = Ribes Linn.

Grubbia Berg. Grubbiaceae (the only genus). 3 sp. Cape Col.

Grubbiaceae. Dicotyledons (Archichl. Santalales). Only genus Grubbia. United to Santalaceae by Benth.-Hooker. [See *Nat. Pfl.*]

Guaiacum Plum. ex Linn. Zygophyllaceae. 4 sp. N. and trop. Am. *G. officinale* L. yields the valuable lignum-vitae wood, from which is also obtained the medicinal resin guaiacum.

Guatteria Ruiz et Pav. Anonaceae (2). 50 sp. trop. Am.

Guettarda Linn. Rubiaceae (II. 12). 40 sp. trop., all but one in Am.
Guilandina Linn. = Caesalpinia Linn.
Guilleminea H. B. et K. Amarantaceae (3). 3 sp. Am.
Guizotia Cass. Compositae (V). 5 sp. Afr. *G. abyssinica* Cass. is cultivated for its oily seeds, from which Rantil oil is expressed.
Gunnera Linn. Haloragidaceae. 17 sp. S. Am., N. Z., Tasm., Sandw. Is., Java, S. Afr., Costa Rica. Several sp. are enormous herbs with very handsome leaves several feet across. They grow by the side of water and deserve more attention as ornamental plants than they have hitherto received. Flr. 2-merous. Ovary 1-loc. Stem polystelic. In the leaf-axils are 'squamulae intravaginales' (cf. Potamogetonaceae). [See Jonas' Inaug. Diss., abstr. in *Beihefte z. Bot. Cent.* 1894, p. 32.]
Gurania Cogn. Cucurbitaceae (II). 49 sp. trop. Am.
Gustavia Linn. (*Japarandiba* Adans.). Lecythidaceae. 20 sp. trop. Am. *G. augusta* L. is the stink-wood; the wood has a fœtid smell.
Gutierrezia Lag. Compositae (III). 20 sp. Am.
Guttiferae. Dicotyledons (Archichl. Parietales). 42 gen. with 450 sp. chiefly trop. As defined by Engler, the order includes the Hypericaceae of Bentham and Hooker (and other authors) as well as a few of the Ternstroemiaceae. They are (exc. Hypericum) trees or shrubs with simple entire opp. exstip. leaves. Oil glands or passages are always present, often showing as translucent dots upon the leaves. The infl. is cymose, frequently umbellate. The flrs. show considerable variety in structure. The bracteoles are frequently close up to the calyx, and hardly to be distinguished from it. The axis is usually convex, but exhibits many forms. The flr. may be cyclic or partly spiral, and is usually regular, ☿, hypogynous. Calyx imbricate. Corolla imbricate or convolute. Sta. ∞, free or united in various ways, frequently in bundles (usually regarded as due to branching of originally simple papillae); very commonly the outer ones or even all of the sta. are staminodial. $\underline{G}$ usually (5) or (3), multi- or 1-loc.; ovules ∞, few, or 1, anatropous; styles free or united. Fruit often capsular, sometimes a berry or drupe. Seed exalbuminous. [For details of the great variety in floral structure, see Engler in *Nat. Pfl.*] Many yield useful timber; the resins of Clusia, Garcinia, Calophyllum, &c., and the fruits of Garcinia and others are valuable.

Classification and chief genera (after Engler): the G. are closely allied to Theaceae, the only constant distinction being the presence of oil-glands, and to Dipterocarpaceae, which are chiefly distinguished by their alt. stip. leaves. The characters of the sub-orders would occupy too much space, and we give therefore only those of the Hypericoideae, which are often made into an independent order.

I. *KIELMEYEROIDEAE*: Kielmeyera, Caraipa.

II. *HYPERICOIDEAE* (leaves opp.; flr. ☿; sta. usually ∞, usually in 5 or 3—8 bundles before the petals; styles 3—5, usually free; fruit a 1- or 3-loc. septi- or loculi-cidal capsule, or indehiscent; embryo usually straight with not very thick cotyledons): Hypericum, Vismia.

III. *ENDODESMIOIDEAE* (placed in Hypericaceae by Benth.-Hooker; sta. united into a tube above, in 5 bundles below; cpl. 1; drupe; cotyledons fleshy): Endodesmia (only genus).

IV. *CALOPHYLLOIDEAE*: Mesua, Mammea, Calophyllum.

V. *CLUSIOIDEAE*: Clusia, Garcinia.

VI. *MORONOBOIDEAE*: Symphonia.

[Placed in Guttiferales by Benth.-Hooker, in Cistiflorae by Warming.]

Guzmania Ruiz et Pav. Bromeliaceae (4). 5 sp. trop. S. Am. Epiphytes.

Gymnadenia R. Br. = Habenaria Willd. (spec. names mostly the same).

Gymnema R. Br. Asclepiadaceae (II. 4). 25 sp. W. Afr. to Austr. The leaves of *G. sylvestre* R. Br. contain gymnemic acid, and when chewed temporarily destroy the capacity of tasting sugar.

Gymnocladus Lam. Leguminosae (II. 7). 2 sp. China and N. Am.

Gymnogramme Desv. Polypodiaceae. 90 sp., esp. trop. *G. leptophylla* Desv., an annual fern, occurs in Jersey.

Gymnospermae. One of the two great divisions of Spermaphyta or seed-plants. They are distinguished from the Angiospermae by the fact that the cpls. are not so infolded or united as to form an ovary round the ovules; also the endosperm (female prothallus) is formed before fertilisation. The existing G. are divided into three great classes, Cycads, Conifers, and Gnetaceae. These differ very much from one another and possibly have been derived from separate stocks of Pteridophyta. The Cycads are connected with the Ferns by the fossil Cycadofilices (*cf.* Scott in *Nature*, 68, 1903. p. 377). The position of the Gnetaceae is peculiar and in some ways nearer to the Angiosperms. The flrs. in most Cycads and Conifers take the form of cones: whether each cone represents one flr. or one infl. is a disputed point (see p. 61, and art. Coniferae). The sta. is of simple structure; in the Cycads there are several pollen-sacs, looking just like the sporangia of Marattiaceae, upon the lower side of a somewhat leaf-like organ; in the Conifers the sta. has usually fewer pollen-sacs and is more leaf-like, while in the Gnetaceae the anthers are sessile. The ovules are always naked in the sense of not being enclosed in an ovary formed of one or more hollow cpls., but they are usually protected in some way from the weather. Wind-pollination occurs.

In the Cycads a considerable mass of sporogenous tissue is formed in the ovule (mega-sporangium); one of the cells of this tissue gives rise to the embryo-sac (mega-spore). This behaviour is closely comparable to that of the higher Pteridophyta. In the embryo-sac the female prothallus (endosperm) forms by cell-division, and archegonia in which the ova are contained develope at the micropylar end. The ovule is now mature and consists of an integument, nucellus, and embryo-sac and its contents.

In most Conifers the sporogenous tissue consists only of the cell which goes to form the embryo-sac. In the sac the same process goes on as in Cycads.

In Ephedra the phenomena are very similar to those in Conifers; in Gnetum several embryo-sacs are formed, and the division of the nucleus of the sac gives rise, not to a prothallus as in the cases above described, but to a number of free nuclei lying on the wall of the sac. The male nucleus fuses with one of these and the rest then give rise to the endosperm. Here we have an intermediate phase between Conifers or Cycads and Angiosperms, more especially some of the Chalazogamae (q. v.).

The pollen-grains come to rest on the nucellus; in some cases the ♂ nuclei take the form of spermatozoids (*Ann. of Bot.* XI. 1897, p. 344). The relationships and classification of the G. are hard to decide. Probably Ginkgo, usually included in Coniferae, should have a class apart. [*Cf.* Angiospermae, Chalazogamae, Pteridophyta, Spermaphyta, Cycadaceae, Coniferae, Gnetaceae, Ginkgo; Celakovsky in *Engl. Jahrb.* XXIV.; Coulter in *Bot. Gaz.* XXVI. 1898, p. 153; Kolkwitz (Litteraturbericht) in *Engl. Jahrb.* XXIX.; Karsten (on Juglandaceae) in *Flora*, 90, p. 316; Oliver in *Ann. of Bot.* XVII, 1903, p. 451; Scott, quoted above; Seward and Gowan in *Ann. of Bot.* XIV. 1900, p. 108.]

Gymnosporia Benth. et Hook. f. Celastraceae. 60 sp. trop. and subtrop., esp. Afr. Many have branches modified into thorns.

Gynandropsis DC. (*Pedicellaria* Schrank). Capparidaceae (I). 15 sp. trop. The seeds of *G. pentaphylla* DC. are used like mustard.

Gynerium Humb. et Bonpl. Gramineae (X). 3 sp. trop. and warm temp. *G. argenteum* Nees is the Pampas grass, often cultivated as a show plant. It is diœcious.

Gypsophila Linn. Caryophyllaceae (I. 2). 50 sp. Eur., As., esp. in E. Medit. region. The flrs. are shorter in the tube than those of most Silenoideae, and are in consequence visited by a greater variety of insects.

Habenaria Willd. (incl. *Bonatea* Willd., *Coeloglossum* Hartm., *Gymnadenia* R. Br., *Neotinea* Rchb. f., *Nigritella* Rich., *Platanthera* Rich., and other gen. often regarded as separate, *e.g.* by Pfitzer in *Nat. Pfl.*) Orchidaceae (3). 400 sp. temp. and trop.; 5 in Brit., *H.* (*C.*) *viridis* R. Br. (frog-orchis), *H.* (*G.*) *conopsea* Benth. (scented orchis), *H.* (*P.*) *bifolia* R. Br. (butterfly orchis), &c. See Darwin's *Orchids*.

Hablitzia Bieb. Chenopodiaceae (2). 1 sp. Caucasus. A climbing shoot is given off each year from the perennial underground stem (cf. Bowiea).

Habrothamnus Endl. = Cestrum Linn.

Hacquetia Neck. Umbelliferae (3). 1 sp. S. Eur.

Haemanthus (Tourn.) Linn. Amaryllidaceae (I). 60 sp. S. Afr. Flrs. in cymose heads or umbels.

Haematoxylon Linn. Leguminosae (II. 7). 1 sp. trop. Am. *H. campechianum* L., the logwood. The young foliage is red (p. 157). In the leaf-axils are thorns. The heart-wood contains the dye-stuff haematoxylin and is largely used in dyeing; it is broken into chips before use.

Haemodoraceae. Monocotyledons (Liliiflorae). 9 gen. with 33 sp., Austr., S. Afr., trop. Am. Herbs with panicled infl., consisting of a number of cymes arranged in a racemose way (cf. Aesculus). Flr. regular or transversely zygomorphic (cf. Anigozanthos), ☿, 3-merous. Sta. 3, inserted on inner perianth-leaves, with introrse anthers. G (3), sup. or inf.; ovules few in each loc., semi-anatropous. Stigma capitate. Capsule. *Chief genera:* Haemanthus, Lachnanthes, Wachendorfia. [As defined by Benth.-Hooker, the order includes sub-orders VIII, IX of Liliaceae, and part of sub-order III of Amaryllidaceae (Anigozanthos, &c.). It is placed in Epigynae by Benth.-Hooker, in Liliiflorae by Warming.]

Haemodorum Sm. Haemodoraceae. 17 sp. Austr.

Hakea Schrad. Proteaceae (II). 100 sp. Austr. Xerophytes with hard woody fruit. The seedlings show interesting transition stages (p. 29, and cf. Acacia) from entire leaves to the much divided leaves usually seen in the genus.

Halenia Borckh. Gentianaceae (I. 3). 25 sp. As., Am.; alpine and arctic.

Halesia Linn. Styracaceae. 7 sp. Japan, China, and S. E. of N. Am. (cf. Epigaea, &c.). The Snowdrop-tree. Fruit winged.

Halimocnemis C. A. Mey. Chenopodiaceae (10). 10 sp. Cent. As.

Halimodendron Fisch. Leguminosae (III. 6). 1 sp. N. and W. As. on salt-steppes. The outer leaflets are often thorny (p. 167).

Halleria Linn. Scrophulariaceae (II. 6). 8 sp. Afr., Madag.

Haloragidaceae. Dicotyledons (Archichl. Myrtiflorae). 8 gen. with 90 sp., cosmop., but chiefly Austr. Land, marsh, or water plants, herbaceous, of very various habit (see gen.), and with inconspicuous flrs., solitary or in infl. The anatomy of the water forms is of interest, and also that of Gunnera, whose stem is polystelic. Flr. ☿ or unisexual, usually bracteolate, regular, epigynous, usually 4-merous. Perianth in two whorls, or one, or absent. Sta. 8, obdiplostemonous, or fewer (down to 1 in Hippuris). Cpls. (1—4); ovary inf., multiloc., with usually 1 pendulous anatropous ovule in each loc.; styles free. Nut or drupe. Embryo straight, in endosperm. *Chief genera:* Haloragis, Myriophyllum, Gunnera, Hippuris. The H. are undoubtedly related to Onagraceae, as reduced forms. A gradual series may be traced, from the very complete flr. of Myriophyllum or Haloragis, down to that of Hippuris. Eichler and Warming also place the order in Myrtiflorae, whilst Benth.-Hooker add to it the Callitrichaceae and place it in Rosales.

Halorageae (Benth.-Hooker) = Haloragidaceae.

Haloragis Forst. Haloragidaceae. 50 sp. Austr., N. Z., Tasm., S.E. As., N. Am. Large herbs living in damp places. Flrs. 4-merous throughout, obdiplostemonous.

Haloxylon Bunge. Chenopodiaceae (10). 10 sp. N. temp. and sub-trop. Steppe plants of curious habit (fig. in *Nat. Pfl.*).

Hamamelidaceae. Dicotyledons (Archichl. Rosales). 18 gen. with 50 sp. chiefly sub-trop. (N. and S.). The distribution areas of the genera (q.v.) are extremely disjointed, a fact probably due to the influence of the glacial period (p. 146 and *Nat. Pfl.*). They are closely allied to Cunoniaceae, and hence to Saxifragaceae. Trees and shrubs with alt., simple or palmate, stip. leaves. Infl. racemose, often a spike or head, frequently with an involucre of coloured bracts. Flr. ☿ or unisexual, often apetalous, rarely naked, hypo- peri- or epigynous, usually without a disc. K 4—5, usually imbricate; C 4—5, open or valvate, the petals often long and rolled up like a watch-spring in bud; A 4—5 or rarely fewer; G (2), usually median, rarely obliquely placed, with 2 styles, 2-loc.; ovules 1 or more in each loc., pendulous, anatropous, with ventral or lateral raphe. Loculicidal or septicidal capsule. Exocarp woody, endocarp horny. Seed albuminous, with straight embryo. Some sp. yield useful wood, resins, &c. *Chief genera:* Bucklandia, Liquidambar, Altingia, Fothergilla, Hamamelis. [Placed in Saxifraginae by Warming, in Rosales by Benth.-Hooker.]

Hamamelideae (Benth.-Hooker) = Hamamelidaceae.

Hamamelis Gronov. ex Linn. Hamamelidaceae. 3 sp., two in China and Japan, the other, *H. virginiana* L., the witch-hazel, in east N. Am. This sp. is common in gardens. It flowers in late autumn and ripens its fruit (which is said to be explosive) in the following year.

Hanburia Seem. Cucurbitaceae (IV). 1 sp. Mexico. Fruit explosive.

Haplopappus Endl. = Aplopappus Cass.

Hardenbergia Benth. Leguminosae (III. 10). 3 sp. Austr. Included in Kennedya in *Nat. Pfl.*

Harpagophytum DC. Pedaliaceae. 3 sp. S. Afr. *H. procumbens* DC. is the grapple-plant; its fruit is beset with large woody grapples about an inch long, pointed and barbed. It is thus well adapted to animal distribution, and is troublesome to wool growers (cf. Xanthium).

Hartwegia Lindl. Orchidaceae (13). 2 sp. Cent. Am.

Hauya (Moç. et Sesse) ex DC. Onagraceae (III). 4 sp. Mexico, Calif.

Haworthia Duval. Liliaceae (III). 100 sp. S. Afr. Xerophytes with fleshy leaves, similar in habit to Crassulaceae.

Hebenstretia Linn. Scrophulariaceae (II. 9). 20 sp. S. Afr. The corolla is slit open along the anterior side, and the style and sta. project through the slit. [Selagineae Benth.-Hooker.]

Hedeoma Pers. Labiatae (VI. 11). 12 sp. Am.

Hedera Tourn. Araliaceae. 3 sp. temp. Old World. *H. Helix* L. is the ivy. It is a root climber on trees and rocks. The leaves are dimorphic, those on the climbing shoots being lobed, whilst those on the freely projecting shoots that bear the infl. are not. The former form leaf-mosaics better (see pp. 46 and 173). The flrs. are not very conspicuous, but coming out late in the year are largely visited for the freely exposed honey by flies and wasps.

Hedraeanthus Griseb. = Wahlenbergia Schrad. (11 sp. S.E. Eur., W. As.)

Hedwigia Sw. Burseraceae. 3 sp. trop. Am. *H. balsamifera* Sw. (Antilles) is known as pig's balsam, on account of a legend that wounded pigs rub themselves against the trees to heal their wounds with the resin.

Hedycapnos Planch. = Dicentra Bernh.

Hedycaria Forst. Monimiaceae. 10 sp. Austr. to Fiji.

Hedychium Koen. Zingiberaceae. About 30 sp. chiefly trop. As. The rhizome is often tuberous. The flr. has a long tube, at the end of which spring the very narrow free parts of the petals and the larger staminodes and labellum. The stigma projects just beyond the anther. According to F. Müller and others the flr. is adapted for fertilisation by the wings of butterflies.

Hedyotis Linn. Rubiaceae (I. 2). About 120 sp. trop. Incl. in Oldenlandia in *Nat. Pfl.*

Hedypnois Schreb. = Rhagadiolus Tourn.

Hedypnois (Tourn.) Scop. = Leontodon Linn.

Hedysarum (Tourn.) Linn. Leguminosae (III. 7). 60 sp. N. temp.

Heeria Schlecht. (*Heterocentron* Hook. et Arn.) Melastomaceae (I). 6 sp. Cent. Am. Some of the sta. attract insects, the others pollinate them (cf. Commelina).

Helenium Linn. Compositae (VI). 30 sp. W. Am.

Heleocharis Lestib. = Eleocharis R. Br.

Heliamphora Benth. Sarraceniaceae. 1 sp. Guiana, a pitcher plant (p. 178 and cf. Sarracenia), not yet thoroughly studied.

Helianthemum Tourn. ex Hall. Cistaceae. 120 sp. Eur., Medit., N. Am. *H. vulgare* Gaertn. and 3 others in Brit. (rock-rose). Infl. a cincinnus. The flr. contains no honey and is homogamous, with sensitive sta., which move outwards when touched.

Helianthus Linn. Compositae (V). 55 sp. Am. Several sp. are widely cultivated. *H. annuus* L. is the sunflower; the number of flrs. upon the head is often enormous and they show very regular spiral arrangement, probably due (largely) to pressure in the bud. The ray florets are neuter. *H. tuberosus* L. is the Jerusalem artichoke. It has subterranean tuberous stems, like potatoes, with well marked 'eyes' (buds in axils of scale-leaves).

Helichrysum Vaill. ex Linn. Compositae (IV). 300 sp. Eur., As., Afr., Austr. About 150 occur in S. Afr. Many are xerophytes with hairy surface, decurrent leaves, &c. The dried flower-heads of some sp. are sold as 'everlastings.'

Helicodiceros Schott. Araceae (VII). 1 sp. Corsica, Sardinia, *H. crinitus* Schott (*H. muscivorus* Engl.). The development of the pedate leaf is cymose; the later formed branches grow more slowly than the earlier. The specific name *muscivorus* is due to the number of flies captured; they are attracted by the foul smell of the infl. (cf. Arum) and collect inside the spathe in enormous numbers (in the Bot. Gdn. Cambridge, the whole spathe may often be seen tightly packed with them); when it withers the top closes and they are caught.

Heliconia Linn. Musaceae. 30 sp. trop. Am. Flrs. in cincinni. The odd sepal is posterior.

Helicteres Pluk. ex Linn. Sterculiaceae. 40 sp. trop. (exc. Afr.). The flrs. become zygomorphic if they happen to be in a horizontal position.

Heliophila Burm. f. ex Linn. Cruciferae (I. 3). 60 sp. S. Afr.

Heliopsis Pers. Compositae (V). 7 sp. Am.

Heliotropium (Tourn.) Linn. Boraginaceae (III). 220 sp. trop. temp. *H. peruvianum* L. (cherry pie) and other sp. of heliotrope are cultivated for their scented flrs.

Helipterum DC. Compositae (IV). 48 sp. Austr., S. Afr. Xerophytes with persistent involucre of white scaly bracts; the dried flower-heads are sold as 'everlastings' (cf. Helichrysum, &c.).

Helleborus (Tourn.) Linn. Ranunculaceae (2). 15 sp. Eur.; 2 in Brit. (Hellebore). The plants are woody below, each shoot from the stock taking several years to reach maturity and flower. Flr. protogynous, opening very early in the year. Cpls. slightly coherent at base. In *H. niger* L., the Christmas rose, the perianth turns green after the flr. has been fertilised.

Helminthia Juss. = Picris Linn.

Helminthostachys Kaulf. Ophioglossaceae. 1 sp. *H. zeylanica* Hk. f., Ceylon, Himal. to Queensland. Rhizome dorsiventral with 2-ranked leaves on the upper side, and roots below. The roots do not bear any definite relation to the leaves. Sporangia peltate, on sporangiophores from the sides of the fertile spike. [Cf. Farmer and Freeman, in *Ann. of Bot.* XIII. 1899, p. 421; Lang on prothallus, do. XVI. 1902, p. 23.]

Helobieae. The 2nd cohort of Monocotyledons (1st of Warming).

Helonias Linn. Liliaceae (1). 1 sp. east N. Am.

Helosciadium Koch = Apium Tourn.

Helosis Rich. Balanophoraceae. 3 sp. trop. Am.

Hemerocallis Linn. Liliaceae (III). 5 sp. temp. Eur., As. Infl. a double bostryx. The flrs. of *H. fulva* L. are self-sterile.

Hemionitis Linn. Polypodiaceae. 8 sp. trop.

Hemitelia Br. Cyatheaceae. About 20 sp. trop. and S. temp. Tree-ferns.

Hemizonia DC. Compositae (v). 25 sp. west N. Am.

Hepatica Dill. = Anemone Linn.

Heptapleurum Gaertn. Araliaceae. About 50 sp. trop. Afr., As., Austr. Included in Schefflera in *Nat. Pfl.*

Heracleum Linn. Umbelliferae (7). 70 sp. N. temp., and trop. Mts. (*H. Sphondylium* L., cow-parsnip, in Brit.).

Herbertia Sweet (*Alophia* Herb.). Iridaceae (II). 3 sp. trop. and sub-trop. Am.

Heritiera (Dryand.) Ait. Sterculiaceae. 4 sp. trop. Old World, on sea coasts.

Hermannia Linn. (excl. *Mahernia* Linn.). Sterculiaceae. 120 sp. trop. and sub-trop., chiefly Afr.

Herminiera Guill. et Perr. Leguminosae (III. 7). 1 sp. trop. Afr., *H. elaphroxylon* G. et P. The wood is as light as elder pith and is used for floats, canoes, &c. This phenomenon seems to be related to the development of aerenchyma seen in other marsh plants (cf. Lycopus, Jussieua, &c., and see p. 161). H. is united to Aeschynomene in *Nat. Pfl.*

Herminium Linn. Orchidaceae (3). 4 sp. temp. Eur., As. (*H. Monorchis* R. Br., musk-orchis, in Brit.). Flr. like that of orchis, but smaller, and fertilised by small flies which get the pollinia stuck to their legs.

Hernandia Plum. ex Linn. Hernandiaceae. 8 sp. trop. (Laurineae Benth.-Hooker).

Hernandiaceae. Dicotyledons (Archichl. Ranales). 4 gen. with 24 sp. trop. Like Lauraceae, to which they are united by Benth.-Hooker and Warming, but with epigynous flr. Ovary inf., 1-loc., with 1 pendulous anatropous ovule. See *Nat. Pfl.* for details.

Herniaria (Tourn.) Linn. Caryophyllaceae (II. 4). 15 sp. Medit., Eur., S. Afr. (*H. glabra* L., rupture-wort, in S. W. England.) Flr. apetalous.

Herpestis Gaertn. (*Bacopa* Aubl.) Scrophulariaceae (II. 8). 50 sp. trop. and sub-trop., chiefly Am.

Hesperantha Ker-Gawl. Iridaceae (III). 20 sp. S. Afr.

Hesperis Linn. Cruciferae (IV. 19). 24 sp. Eur., Medit.; (1 Brit.).

Heteranthera Ruiz et Pav. Pontederiaceae. 10 sp. trop. and sub-trop. Am., Afr. Leaves of two types—linear submerged and orbicular floating. Some have cleistogamic flrs.

Heterocentron Hook. et Arn. = Heeria Schlecht.

Heteromerae (Benth.-Hooker). The 2nd series of Gamopetalae (p. 134).

Heteropteris H. B. et K. Malpighiaceae (I). 90 sp. trop. Am., 1 in trop. Afr. Fruit a samara (cf. Acer, Banisteria).

Heterotoma Zucc. Campanulaceae (III). 4 sp. Mexico.

Heterotropa Morr. et Dcne. = Asarum Linn.

Heuchera Linn. Saxifragaceae (I). 24 sp. N. Am. Flrs. sometimes apetalous.

Hevea Aubl. Euphorbiaceae (A. II. 3). 10 sp. trop. Am. *H. brasiliensis* Mull.-Arg., now largely cult. in Ceylon &c., is the source of the best caoutchouc (Para rubber); incisions are made in the bark, and the latex is collected and coagulated. [*Cf.* p. 199, and literature p. 197.]

Hexaptera Hook. Cruciferae (I. 2). 6 sp. temp. S. Am. Fruit winged.

Hibbertia Andr. (incl. *Candollea* Labill. 1806). Dilleniaceae. 100 sp. Austr., New Caled. &c. Mostly shrubs of ericoid or climbing habit. Some sp. have phylloclades. Infl. dichasial, but often, by reduction, coming to look like a raceme. The sta. &c. vary much in number in different sp. (see *Nat. Pfl.*).

Hibiscus Linn. (incl. *Abelmoschus* Medic.). Malvaceae (IV). 150 sp. trop. and sub-trop. The 5 ante-sepalous sta. are represented by teeth at the top of the stamen-tube. Several sp. are cultivated, especially *H. Rosa-sinensis* L. (flrs. showy), *H. Sabdariffa* L. (Rozelle, fruit for jelly &c.), *H.* (*A.*) *esculentus* L. (Okra or Bandakai, mucilaginous young fruit in soups, &c.).

Hieracium (Tourn.) Linn. Compositae (XIII). 400 sp. N. Hemisph., S. Afr., Andes. There are several sp. in Brit. (hawk-weeds), which, especially in Scotland, vary very much; innumerable varieties have been raised by various botanists to specify rank (see p. 119 and *London Cat. of Brit. Plants*, 9th ed.).

Hierochloë S. G. Gmel. Gramineae (VII). 13 sp. temp. and frigid. (1 Brit., rare.)

Higginsia Pers. = Hoffmannia Sw.

Hildebrandtia Vatke. Convolvulaceae (I. 3). 2 sp. Afr.

Himantoglossum Spreng. = Orchis Tourn.

Hinterhubera Sch. Bip. Compositae (III). 3 sp. Andes.

Hippeastrum Herb. Amaryllidaceae (I). 50 sp. trop. and sub-trop. Am.

Hippia Linn. Compositae (VII). 4 sp. S. Afr.

Hippocastanaceae. Dicotyledons (Archichl. Sapindales). Only genus Aesculus (q.v.). United to Sapindaceae by Benth.-Hooker.

Hippocratea Linn. Hippocrateaceae. 70 sp. trop. Twining shrubs.

Hippocrateaceae. Dicotyledons (Archichl. Sapindales). 3 gen. with 150 sp. trop. and sub-trop. Shrubs, mostly lianes, with opp. or alt. simple leaves. Flrs. in cymes, ☿, regular, with disc. K 5, C 5, A 3 (rarely 5, 4, 2), $\underline{G}$ (3), with 2—10 anatropous ovules in each loc. Berry or schizocarp. No endosperm. *Genera:* Campylostemon, Hippocratea, Salacia. [United to Celastraceae by Benth.-Hooker; placed in Frangulinae by Warming.]

Hippocrepis Linn. Leguminosae (III. 7). 12 sp. Medit. *H. comosa* L. extends to Scotland. The mechanism of the flr. is like that of Lotus, but on the claw of the standard is a triangular flap closing the entrance to the honey. Bees must lift the standard to reach the honey and so cannot avoid making the mechanism work properly.

Hippomane Linn. Euphorbiaceae (A. II. 7). 1 sp. Cent. Am., W. Ind., Columbia (the manchineel). The latex is highly poisonous.

Hippophaë Linn. Elaeagnaceae. 2 sp., one Himal., the other, *H. rhamnoides* L., the sea buckthorn, from Brit. to Altai Mts. In the ♂ flr. the bracteoles form a hood over the sta. in wet weather; when the air is drier, they separate at the sides, and the pollen may be blown away by wind.

Hippuris Linn. Haloragidaceae. 1 sp., *H. vulgaris* L. the mare's-tail, Eur. (incl. Brit.), As., Austr., Am. A water plant, with creeping rhizome and erect shoots, whose upper parts usually project above the water. Leaves linear, in whorls, the submerged ones longer and more flaccid than the aerial. Flr. sessile in axil of leaf, ☿ (or sometimes ♀ on some stocks; cf. Labiatae), consisting of 1 epigynous sta. and 1 cpl., with a slight seam representing the calyx; wind fertilised.

Hiraea Jacq. (*Mascagnia* Bert.). Malpighiaceae (I). 40 sp. trop. Am.

Hirtella Linn. Rosaceae (VI. 13). 40 sp. S. and Cent. Am., 1 Madag. Flr. zygomorphic. The axis is deeply hollowed on one side, but the sta. and cpl. are not in the hollow, but on the other side of the surface of the axis.

Hodgsonia Hook. f. et Thoms. Cucurbitaceae (III). 1 sp. Indo-mal.

Hoffmannia Sw. Rubiaceae (I. 8). 20 sp. trop. Am.

Holboellia Wall. Lardizabalaceae. 2 sp. Himal.

Holcus Linn. Gramineae (IX). 8 sp. Eur., N. and S. Afr. 2 in Brit., *H. mollis* L., and *H. lanatus* L., Yorkshire fog or soft-grass, a common weed.

Holosteum Dill. ex Linn. Caryophyllaceae (II. 1). 6 sp. N. temp. (1 Brit.).

Homalium Jacq. Flacourtiaceae. 35 sp. trop. After fertilisation the sepals or petals, or both, grow large and form wings (often hairy) to the fruit. (Samydaceae Benth.-Hooker.)

Homalomena Schott. Araceae (V). 20 sp. trop. As. and S. Am.

Homogyne Cass. Compositae (VIII). 3 sp. Mts. of Eur.

Honckenya Ehrh. = Arenaria Rupp. (same spec. name).

Hordeum (Tourn.) Linn. Gramineae (XII). 16 sp. temp. Eur., As., N. Afr., Am. 4 in Brit. (barley-grass). The spikelets are arranged in groups of 3 on the main axis, forming a dense spike. Each is 1-flowered when perfect, but commonly either the central or the two lateral flrs. are aborted. Glumes awned. The cultivated barley is *H. vulgare* L. (*H. sativum* Pers.). The most common form is the var. *distichum* or 2-rowed barley, where the central flr. of each group is fertile, but 6-rowed barley (var. *hexastichum*), and 4-rowed barley or bere, are also grown. The last is the most hardy and is cultivated as far as 70° N. (in Norway).

Horminum (Tourn.) Linn. Labiatae (VI. 9). 1 sp. Mts. of S. Eur.

Hosackia Dougl. Leguminosae (III. 4). 30 sp. west N. Am.

Hosta Tratt. = Funkia Spreng.

Hoteia C. Morr. et Dcne = Astilbe Buch.-Ham.

Hottonia Boerh. ex Linn. Primulaceae (I). 2 sp., one in N. Am., the other, *H. palustris* L. (water-violet), in Siberia and Eur. (incl. Brit.). Floating water-plants (p. 158) with finely-divided submerged leaves. The flrs. project above the water; they are dimorphic like those of Primula. Winter buds form as in Utricularia, &c.

Houstonia Gronov. ex Linn. Rubiaceae (I. 2). 20 sp. west N. Am. Flrs. heterostyled as in Primula, with similar differences in stigma and pollen.

Houttuynia Thunb. Saururaceae. 2 sp. N.W. Am. and E. As.

Howea Becc. Palmae (IV. 6). 2 sp. Lord Howe's Island.

Hoya R. Br. Asclepiadaceae (II. 4). 70 sp. Indo-mal., Austr. Twiners and root-climbers with fleshy leaves. Hothouse favourites on account of their handsome flrs. (wax-flowers).

Hudsonia Linn. Cistaceae. 3 sp. N. Am.

Huernia R. Br. Asclepiadaceae (II. 4). 20 sp. Cape Col. to Arabia. Like Stapelia, but stem 4- to 6-angled.

Hugonia Linn. Linaceae. 11 sp. trop. Old World. The lower twigs of the infl. are modified into hooks for climbing (p. 172).

Humboldtia Vahl (*Batschia* Vahl). Leguminosae (II. 3). 4 sp. Ceylon and Further Ind. *H. laurifolia* Vahl is myrmecophilous (p. 115). The non-flowering twigs are normal, but those that bear flrs. have hollow obconical internodes. In each of these, at the top, opposite the leaf, is a slit leading to the cavity which is inhabited by ants.

Humea Sm. Compositae (IV). 4 sp. S. Austr.

Humiria Jaume St. Hil. Humiriaceae. 3 sp. trop. Am.

Humiriaceae. Dicotyledons (Archichl. Geraniales). 3 gen. with 18 sp., trop. Am., Afr. Separated from Linaceae by the bilocular anthers and usually ∞ sta. (See *Nat. Pfl.*) *Chief genera:* Humiria, Saccoglottis.

Humulus Linn. Moraceae (IV). 2 sp. N. temp. Perennial climbing herbs. Infl. cymose, diœcious, the ♂ a much-branched pseudo-panicle, the ♀ a few-flowered pseudo-catkin with 2 flrs. in the axil of each scale. Flr. protogynous and wind fertilised. Fruit an achene. *H. Lupulus* L. is the hop, largely cultivated in Kent and elsewhere; the fruit is used in brewing, &c.

Hunnemannia Sweet. Papaveraceae (I). 1 sp. Mexico.

Hura Linn. Euphorbiaceae (A. II. 7). 2 or 3 sp. trop. Am., of which the best known is *H. crepitans* L., the sand box tree. The fruit is as big as an orange with numerous hard woody cpls. Each, as the ripe fruit dries, tries to expand from the Δ shape to a U shape. Presently a violent explosion occurs and the seeds are shot out, sometimes to a distance of 30 yards. The fruits used to be wired together and used as sand boxes before the era of blotting-paper.

Hutchinsia R. Br. Cruciferae (IV. 14). 8 sp. N. temp. (1 in Brit.)

Hyacinthus (Tourn.) Linn. Liliaceae (v). 30 sp. Medit., Afr. Many forms of hyacinth (derived from *H. orientalis* L.) are cultivated. [For the wild hyacinth of Brit., see Scilla.]

Hydnophytum Jack. Rubiaceae (II. 15). 30 sp. E. As., New Guinea, Fiji, &c. Epiphytes with ant-inhabited tubers, like Myrmecodia (q.v.).

Hydnora Thunb. Hydnoraceae. 7 sp. Afr.

Hydnoraceae. Dicotyledons (Archichl. Aristolochiales). 2 gen. with 7 sp., Afr., S. Am. Parasites like Rafflesiaceae. See *Nat. Pfl.* or Kerner's *Nat. Hist. of Plts.*

Hydrangea Gronov. ex Linn. Saxifragaceae (III). 20 sp. N. Hemisph. Shrubs with opp. leaves, some climbing. Flrs. in cymose corymbs, the outer (or in cultivated forms all the flrs.) neuter with petaloid calyx, giving conspicuousness to the infl. (cf. Compositae, Umbelliferae).

Hydrangeaceae (Warming) = Saxifragaceae (suborder III).

Hydrastis Ellis. Ranunculaceae (I). 2 sp., 1 in Japan, 1 in N. Am. (*H. canadensis* L., golden-seal). The latter is used as a tonic &c.

Hydrocaryaceae. Dicotyledons (Archichl. Myrtiflorae). Only genus Trapa (q.v.). Often placed in Onagraceae.

Hydrocharideae (Benth.-Hooker) = Hydrocharitaceae.

Hydrocharis Linn. Hydrocharitaceae. 1 sp. Eur. (incl. Brit.), As., *H. Morsus-ranae* L., the frog-bit, a rootless water plant with orbicular floating leaves. Flrs. diœcious, produced upon the surface of the water. During summer the plant multiplies much by horizontal stolons, which form new plants at the ends. In autumn large buds are formed on the stolons and drop off to spend the winter at the bottom of the pond. In spring they float up and develope into new plants.

Hydrocharitaceae. Monocotyledons (Helobieae). 13 gen. with about 55 sp. trop. and temp., all water plants, some marine (Halophila, Enalus, Thalassia). Most have ribbon-like submerged leaves, a few only have floating leaves (Hydrocharis &c.); some have leaves projecting above the water. In the leaf-axils are 'squamulae intravaginales' (cf. Potamogetonaceae). Several buds are frequently found in one leaf-axil.

Sexes usually in different flrs., commonly on different plants. Infl. axillary, usually 1-flowered when ♀, often more than 1 if ♂, enclosed at first in a spathe of two or more (1 in Hydrocharis ♀) fused leaves. Flr. usually regular, 3-merous. Perianth usually in two whorls, the outer sepaloid, the inner petaloid; sta. in 1—5 whorls, the innermost often staminodial; cpls. (2—15), forming an inf. ovary, 1-loc. with parietal placentation; ovules ∞, ortho- to ana-tropous, erect to pendulous; stigmas as many as cpls. Fruit irregularly dehiscent, containing ∞ exalbuminous seeds. [Placed in Microspermae by Benth.-Hooker.] *Chief genera:* Halophila, Elodea, Vallisneria, Stratiotes, Hydrocharis.

Hydrocleys Rich. Butomaceae. 1 sp. Brazil, *H. nymphoides* Buchenau

(=*H. Commersonii* Rich.=*Limnocharis Humboldti* Rich.), often cultivated; it is a water plant with a striking resemblance in habit to Nymphaea or Limnanthemum.

Hydrocotyle (Tourn.) Linn. Umbelliferae (I). 70 sp. trop. and temp. 1 in Brit., *H. vulgaris* L., the white-rot or pennywort, easily recognised among our native U. by its peltate leaves.

Hydrolea Linn. Hydrophyllaceae. 12 sp. trop. Several have axillary thorns (branches). Flr. self-fertilising (cf. Phacelia).

Hydromystria G. F. W. Mey.=Limnobium Rich. (*H. stolonifera* G. F. W. Mey.=*L. Boscii* Rich.).

Hydrophyllaceae. Dicotyledons (Sympet. Tubiflorae). 17 gen. with 170 sp., chiefly in N. Am. where some of the gen. are in vigorous development; in S. Am., trop. As., Afr., &c. a few sp. occur, apparently the remnants of formerly wide-spread gen. Herbs or undershrubs with simple or compound exstip. leaves, radical, alt. or opp. Plant usually hairy. Flrs. scattered or in cincinni like those of Boraginaceae, usually without bracteoles, ☿, regular, usually 5-merous. K (5), imbricate, the odd sepal posterior; C (5), rotate, or bell- or funnel-shaped, usually imbricate; A 5, epipetalous and alternate with pets., often with scale-like appendages at base (see below); $\underline{G}$ (2), 1—2- loc., with 1 or 2 styles. Ovules on each cpl. ∞—2, sessile or pendulous, anatropous. Fruit usually a loculicidal capsule. Embryo small, in rich endosperm. The flrs. in most investigated sp. are visited chiefly by bees; honey is secreted below the ovary and protected by the appendages of the sta., which are frequently united to the corolla, sometimes (Hydrophyllum) forming tubes leading down to the honey. Flr. usually protandrous. See Phacelia. *Chief genera:* Hydrophyllum, Nemophila, Phacelia, Nama, Hydrolea. [Placed in Polemoniales by Benth.-Hooker, in Tubiflorae by Warming.]

Hydrophyllum Linn. Hydrophyllaceae. 6 sp. N. Am. Flr. protandrous, with the staminal appendages united to the corolla so as to form tubes through which alone the honey is accessible.

Hydropyrum Link=Zizania Gronov.

Hygrophila R. Br. Acanthaceae (IV. B). 30 sp. trop., in marshes.

Hymenaea Linn. Leguminosae (II. 3). 8 sp. trop. Am. *H. Courbaril* L. is the West Indian Locust tree, a large tree with buttress roots (p. 40). The wood is valuable. From the stem exudes a resin (copal or anime) which is often found in lumps underground near the trees (cf. Agathis, Trachylobium); it is used in varnish, &c.

Hymenocallis Salisb. Amaryllidaceae (I). 30 sp. trop. Am. The stipular appendages of the sta. are here united into a tube, on the summit of which the filaments stand, and which surpasses the perianth in conspicuousness (cf. Eucharis).

Hymenopappus L'Hérit. Compositae (VI). 11 sp. N. Am.

Hymenophyllaceae. Filicineae Leptosporangiatae (Homosporous).

3 gen. with 200 sp. trop. and temp. The filmy ferns are found chiefly in damp woods. Stem very slender, often creeping; sometimes it bears roots, in other cases only root hairs. It grows more rapidly than the leaves, so that its leafless tip appears naked like a root. Leaves pinnate, filmy in texture (being only one cell thick, except at the veins), with no stomata. The placenta is at the leaf-edge, a continuation of the vein; it bears sporangia and is surrounded by a cup-shaped indusium. Sporangia sessile, with oblique or transverse complete annulus, and opening by a longitudinal fissure. The prothalli are capable of long life; in some sp. they produce *gemmae* or buds on the margin, and may thus multiply vegetatively to a considerable extent. *Chief genera:* Hymenophyllum, Trichomanes.

Hymenophyllum Linn. Hymenophyllaceae. Over 80 sp. trop. and temp. 2 in Brit. (filmy ferns), *H. tunbridgense* Sm. and *H. Wilsoni* Hook, moss-like plants growing in damp, shady places.

Hymenophysa C. A. Mey. Cruciferae; position in the order doubtful. 2 sp. Cent. As. See *Nat. Pfl.*

Hyophorbe Gaertn. Palmae (IV. 6). 3 sp. Mascarenes.

Hyoscyamus (Tourn.) Linn. Solanaceae (II. 3). 11 sp. N. Afr., Eur., As. *H. niger* L. (henbane) is found in Brit., but probably is only an escape, it having formerly been largely cultivated as a narcotic. The flrs. are in cincinni. The capsule stands erect enclosed in the calyx, and opens by a lid; the seeds can thus only escape in strong winds, &c.

Hyoseris Linn. Compositae (XIII). 3 sp. Medit.

Hypecoum Tourn. ex Linn. Papaveraceae (I). 12 sp. Medit., Cent. As. Flr. 2-merous throughout. The inner petals are 3-sect, and the middle lobe stands erect and encloses the sta. Eichler (*Blüthendiag.*) and others regard the andrœceum as derived from the Fumaria type by union in pairs of the lateral branches of the outer whorl of sta., so as to form an apparent inner whorl of sta., but it is quite probable that the 2 inner sta. are really a true inner whorl. As in other cases, the evidence cuts both ways, and may be used as proof of the derivation of the Fumaria type from Hypecoum by splitting of the two inner sta. and the union of the halves to the outer ones. In *H. procumbens* L. the pollen is shed in the bud into pockets on the inner surface of the inner petals, which close up before the stigma developes. When pressed by an insect the pockets open and dust it with pollen. The stigma only ripens after it has grown above the level of the pollen.

Hypericaceae (Warming: Cistiflorae) = Hypericineae (Benth.-Hooker: Guttiferales). Chief genus Hypericum; merged in Guttiferae (q.v.).

Hypericum Tourn. ex Linn. Guttiferae (II). 200 sp. temp. (11 Brit., St John's wort, tutsan, &c.). They are nearly all perennial herbs with opp., often gland-dotted leaves and cymes of flrs., often forming pseudo-racemes or -umbels. Sta. ∞, but united into 3 or 5 groups. Developmental study shows that each of these groups arises as a simple papilla from the growing point, and afterwards branches; a comparison with other Guttiferae however shows that in H. we have more probably to do with a union of originally free sta. (see *Nat. Pfl.*, or Pax, *Morphol.* p. 238). The flrs. contain no honey, but offer abundant pollen to insects, and the larger-flowered sp. are frequently visited. They are homogamous, but the stigmas stick out through the sta. and there is thus a chance of a cross when insects alight on the petals.

Hyphaene Gaertn. Palmae (II. 3). 9 sp. trop. Afr. The stem is frequently branched, a rare occurrence in Palms.

Hypochoeris Linn. Compositae (XIII). 50 sp. N. temp. and S. Am. (3 in Brit.).

Hypoderris Br. Polypodiaceae. 1 sp. W. Ind.

Hypoestes Soland. Acanthaceae (IV. B). 85 sp. trop. Old World, esp. Madag.

Hypolepis Bernh. Polypodiaceae. 12 sp. trop. and S. temp. 1 in Calif.

Hypopitys Dill. ex Adans. = Monotropa Linn.

Hypoxis Linn. Amaryllidaceae (III). 50 sp. S. Afr.

Hyptis Jacq. Labiatae (VII). 250 sp. trop., chiefly Am.

Hyssopus (Tourn.) Linn. Labiatae (VI. 11). 1 sp. Eur., Medit., As., *H. officinalis* L., the hyssop, formerly used in medicine.

Hysterophyta (Warming). The last cohort of Choripetalae (p. 137).

Iberis Dill. ex Linn. Cruciferae (II. 6). 30 sp. Eur., As. *I. amara* L. is the candytuft. The outer petals of the flrs. of the corymb are longer than the rest, thus adding to the conspicuousness of the whole (cf. Umbelliferae).

Icacinaceae. Dicotyledons (Archichl. Sapindales). 38 gen. with 200 sp., trop. Trees and shrubs (often lianes) or rarely herbs, with. alt. exstip. leaves, usually entire and often leathery. Flrs. in compound panicled infl., regular, usually ☿. K (5) or (4), not enlarged when the fruit is ripe; C 5 or 4, rarely united, valvate or imbricate; A 5 or 4, alt. with petals, with usually introrse anthers; disc rarely developed; $\underline{G}$ (3) or rarely (5) or (2), rarely multi-loc., usually 1-loc. by abortion of the remaining cavities. Ovules 2 per loc., pendulous from its apex, anatropous, with dorsal raphe and micropyle facing upwards; funicle usually thickened above the micropyle. Style simple with 3 stigmas (or 5—2). Fruit 1-loc., 1-seeded, usually a drupe, sometimes a samara. Endosperm usually present; embryo straight or curved. *Chief genera:* Lasianthera, Phytocrene. [This order was formerly sunk in Olacaceae (*e.g.* by Benth.-Hooker), but differs in several points; the placenta is never free, the flr. has only one whorl of sta., &c. It is placed in Terebinthinae by Warming.]

Idesia Maxim. Flacourtiaceae. 1 sp. China, Japan. [Bixineae, Benth.-Hooker.]

Ilex (Tourn.) Linn. Aquifoliaceae. 170 sp. Cent. and S. Am., As., Afr., Austr., Eur. *I. Aquifolium* L., the holly, in Brit. Flrs. dioecious, but in the ♀ flr. the sterile sta. are so large that the flr.

appears ☿. Truly ☿ flrs. sometimes occur. *I. paraguensis* A. St Hil. is the Maté or Paraguay tea, largely used in S. Am. The leaves contain caffeine; they are dried, broken up and used like tea.

Ilicineae (Benth.-Hooker) = Aquifoliaceae.

Illecebraceae (Benth.-Hooker) = Paronychiaceae of other authors. Now placed in Caryophyllaceae (q.v.).

Illecebrum Rupp. ex Linn. Caryophyllaceae (II. 4). 1 sp. W. Eur. (incl. Devon and Cornwall), Medit., W. Afr.

Illicium Linn. Magnoliaceae (3). 7 sp. Am., As. *I. verum* Hook. fil. the star-anise (China), is used for flavouring on account of the aromatic oil it contains, especially in the fruit. There is a gradual transition in the spiral perianth from sepaloid to petaloid structure (cf. Nymphaea). The fruit is an aggregate of follicles.

Illipe F. Muell. = Bassia Koenig.

Impatiens Riv. ex Linn. Balsaminaceae. 140 sp. trop. and N. temp. Many sp. of balsam are in cultivation, *e.g. I. Noli-tangere* L., the touch-me-not. The name is derived from the explosive fruit. It is a capsule with fleshy pericarp; the outer layers of cells are highly turgid and thus a great strain is put upon the whole. Dehiscence is septifragal and is started by the least touch when the fruit is ripe. The valves roll up inwards with great violence (starting at the base) and the seeds are scattered in all directions.

Incarvillea Juss. Bignoniaceae (II). 5 sp. E. and Cent. As. Leaves alt.

Incompletae (Benth.-Hooker) = Monochlamydeae (see p. 135).

Indigofera Linn. Leguminosae (III. 6). 250 sp. trop. *I. tinctoria* L. and *I. Anil* L. furnish indigo. The plant is mown just before flowering, and soaked in water, whereby a yellowish solution is obtained. This on stirring and exposure to the air oxidises, and an insoluble precipitate of indigo is formed. The flrs. are slightly explosive (cf. Genista).

Inferae (Benth.-Hooker). The 1st series of Gamopetalae.

Inga Scop. Leguminosae (I. 1). 140 sp. trop. and sub-trop. Am.

Inula Linn. Compositae (IV). 90 sp. Eur., As., Afr. (4 in Brit.). The root of *I. Helenium* L., the elecampane, is officinal.

Iochroma Benth. Solanaceae (II. 2). 15 sp. trop. Am. *I. macrocalyx* Miers shows a mode of protection of the flower-buds, similar to that in Spathodea, by watery secretion between calyx and corolla.

Ionidium Vent. Violaceae. 50 sp. trop. and sub-trop. The roots of *I. Ipecacuanha* Vent. are used in medicine under the name of white Ipecacuanha, in the same way as the true drug (see Psychotria).

Ionopsidium Rchb. = Cochlearia Tourn. 1 sp. Portugal, *I. acaule* Rchb. with *solitary* flrs. in the axils of radical leaves.

Ionopsis H. B. et K. Orchidaceae (28). 10 sp. trop. Am., epiphytes.

Ipecacuanha Arruda = Psychotria Linn.

Ipomoea Linn. (incl. *Aniseia* Choisy, *Batatas* Choisy, *Calonyction* Choisy, *Exogonium* Choisy, *Mina* Cerv., *Operculina* Silva Manso, *Pharbitis* Choisy, and *Quamoclit* Moench, all treated as separate genera in *Nat. Pfl.*). Convolvulaceae (I. 4). About 410 sp. trop. and warm temp. Chiefly climbing herbs or shrubs; many are cultivated for their handsome flrs. (*e.g. I. purpurea* Roth, the morning glory). *I. Batatas* Lam. (*B. edulis* Choisy) is the sweet potato, largely cultivated in warm countries for its tuberous roots, which are used like potatoes. *I.* (*Exogonium*) *Purga* Hayne is the Jalap. The rhizome gives off turnip-like roots about the size of apples; they possess purgative properties on account of a resin which they contain.

Iresine P. Br. Amarantaceae (4). 20 sp. Am., Afr.

Iriartea Ruiz et Pav. Palmae (IV. 6). 10 sp. trop. S. Am. The stem is supported on aerial roots (cf. Pandanus), often to a height of 8 feet above the soil. Some of the branches of these roots are thorny (cf. Acanthorhiza). In *I. ventricosa* Mart., the Paxiuba palm, the stem has a peculiar egg-like thickening about half-way up (cf. Bombacaceae, Jatropha).

Iridaceae. Monocotyledons (Liliiflorae). 57 gen. with about 800 sp. trop. and temp.; the chief centres of distribution are S. Afr. and trop. Am. Chiefly herbs with a sympodial tuber or rhizome below ground. Leaves usually equitant in two ranks. Infl. terminal, cymose (1 flr. only in Crocoideae). Flr. ☿, regular or zygomorphic. Perianth 3+3, petaloid, united below into a long or short tube. Sta. 3 (the outer whorl), with extrorse anthers. $\overline{G}$ (3), 3-loc., with axile placentae (rarely 1-loc. with parietal placentae). Style usually trifid and frequently more or less petaloid. Ovules usually ∞, anatropous. Loculicidal capsule. Embryo small, in hard endosperm.

Classification and chief genera (after Pax):

I. *Crocoideae* (flr. solitary, or several developed centrifugally round a central one; plant small; leaves not exactly in ½ phyllotaxy): Crocus, Romulea.

II. *Iridoideae* (flrs. numerous, in spathes, several in each, usually regular; stem distinct; leaves equitant): Iris, Moraea, Tigridia, Sisyrinchium.

III. *Ixioideae* (similar, but spathes 1-flowered; flr. often zygomorphic): Ixia, Tritonia, Gladiolus, Freesia.

[Placed in Epigynae by Benth.-Hooker; Liliiflorae by Warming.]

Irideae (Benth.-Hooker) = Iridaceae.

Iris Tourn. ex Linn. Iridaceae (II). About 100 sp. N. temp. 2 in Brit., *I. Pseudacorus* L., the yellow flag, and *I. foetidissima* L., the gladdon. Many sp. are cultivated. Most sp. have a sympodial rhizome with equitant isobilateral leaves, and small cymes of flrs. in spathes. Perianth petaloid, the sepals usually bending downwards at the outer ends; opposite to them and almost resting on them are the petaloid styles, under which are the sta. with their extrorse anthers. Just above the anther, on the outer side of the style, is a little flap, whose

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upper surface is the stigma. Bees entering the flr. to get the honey secreted by the ovary rub off their load of pollen upon the stigma; going farther in they get a fresh supply of pollen; and when they come out close the stigma flap, which prevents self-fertilisation (cf. Viola). The flat seeds are suited to wind-distribution.

The dried rhizome of *I. florentina* L. smells like violets, it is known as Orris root, and is largely used in perfumery; 'essence of violets' is made from it.

Isatis Tourn. ex Linn. Cruciferae (II. 8). 50 sp. Medit., Eur., As. *I. tinctoria* L. is the woad, largely used as a dye before the introduction of indigo. It is prepared by grinding the leaves to a paste and fermenting them.

Isnardia Linn. = Ludwigia Linn.

Isoetaceae. Lycopodinae (Heterosporous). Only genus Isoetes (q.v.).

Isoetes Linn. Isoetaceae. 50 sp. temp. and trop. *I. lacustris* L. is the quill-wort of Brit. lakes, and *I. echinospora* Dur. is also found. Most sp. are aquatics with short stout rhizomes and awl-shaped leaves, the habit being very like that of Littorella, with which I. is frequently confused. The stem grows in thickness, but very slowly. The leaves spread out at the base and sheath the stem. There are a number of roots, which branch dichotomously. Above the base of each leaf, on the inner side, is a large sporangium sunk in the tissue. The outer leaves have micro- the inner mega- sporangia, whilst the innermost leaves of all are usually small and not sporangiferous. The sporangia are imperfectly chambered up by strands of tissue (*trabeculae*) running across them from front to back. The germination of the spores and the development of the embryo resemble the corresponding processes in Selaginella.

I. is frequently placed with the Eusporangiate Filicineae (see Campbell, *Mosses and Ferns*). It differs so much from all other Pteridophyta that the determination of its relationships is a matter of great difficulty.

Isolepis R. Br. = Scirpus Linn.

Isoloma Dcne. (*Kohleria* Regel). Gesneraceae (II). 40 sp. trop. Am. Several sp. form runners above ground, thickly covered with scaly leaves.

Isonandra Wight. Sapotaceae (I). 6 sp. Ceylon to Sumatra. [*I. Gutta* Hook. = *Dichopsis Gutta*.]

Isopogon R. Br. Proteaceae (I). 29 sp. Austr.

Isopyrum Linn. Ranunculaceae (2). 17 sp. temp. As.

Isotoma Lindl. Campanulaceae (III). 6 sp. Austr., 1 W. Ind., 1 Society Is.

Ixia Linn. Iridaceae (III). 25 sp. S. Afr.

Ixiolirion Fisch. Amaryllidaceae (I). 2 sp. W. As.

Ixora Linn. Rubiaceae (II. 14). 100 sp. trop. The flr. is commonly red with a long narrow tube, and probably, therefore, butterfly-visited (p. 91). The mechanism is like that of Campanula.

Jaborosa Juss. Solanaceae (II. 5). 8 sp. Mexico, temp. S. Am.
Jacaranda Juss. Bignoniaceae (II). 30 sp. trop. Am.
Jacksonia R. Br. Leguminosae (III. 2). 37. sp. Austr.
Jacobinia Moric. Acanthaceae (IV. B). 20 sp. trop. Am.
Jacquemontia Choisy. Convolvulaceae (I. 4). 40 sp. trop. Am., Afr., Sandw. Is.
Jacquinia Linn. Myrsinaceae (I). 6 sp. trop. Am.
Jambosa DC. = Eugenia Mich.
Jasione Linn. Campanulaceae (I. 1). 5 sp. Medit., Eur. *J. montana* L., the sheep's-bit scabious, is common in Brit., especially in hilly districts. The flr. is of interest as affording—like Phyteuma, but in a slightly different way—an intermediate step between Campanula and the Compositae, in the floral mechanism. The tube is formed by the anthers, which cohere at their base, while the petals spread out as soon as the bud opens.
Jasminaceae (Warming) = Oleaceae (suborder II.).
Jasminum (Tourn.) Linn. Oleaceae (II). 160 sp. trop. and sub-trop. Erect or twining shrubs, often cultivated for their sweet scented flrs. (Jasmine). The fruit is vertically constricted into two lobes.
Jasonia Cass. Compositae (IV). 2 sp. Medit.
Jateorhiza Miers. Menispermaceae. 2 sp. trop. Afr. *J. Columba* Miers (*J. palmata* Miers) furnishes Radix Columba, used as a tonic.
Jatropha Linn. Euphorbiaceae (A. II. 3). 70 sp. trop. and sub-trop. *J. podagrica* Hook., frequently cultivated, is a xerophyte with egg-shaped swollen stem, consisting mainly of water-storing tissue; the leaves fall in the dry season (p. 168). The axis of the infl. is red, as well as the flrs. The first branches of the dichasium end in ♀ the later in ♂ flrs. (cf. Begonia).
Jatrorrhiza Prantl = Jateorhiza Miers.
Jeffersonia Bart. Berberidaceae. 2 sp. N. Am., E. As.
Juanulloa Ruiz et Pav. Solanaceae (IV. 7). 10 sp. trop. Am. *J. parasitica* R. et P. is not a parasite, but an epiphyte.
Jubaea H. B. et K. Palmae (V. 7). 1 sp. Chili, *J. spectabilis* H. B. et K., the Coquito-palm. Palm-honey is prepared by evaporation of the sap, and the tree is useful in other ways.
Juglandaceae. Dicotyledons (Archichl. Juglandales). 6 gen. with 40 sp., N. temp., and trop. As. Trees with alt. stip. leaves, with brown hairy winter buds: the buds arise rather high up in the leaf axils, and sometimes several appear in descending order. Infl. monœcious, the ♂ appearing as catkins on the twigs of the previous year, the ♀ as sessile flrs. on the stems of the current year. Perianth typically 4-leaved, but often fewer by abortion. ♂ flr. with 3—40 sta. (more in the lower flrs.); ♀ flr. with epigynous perianth, and 2 cpls. Ovary syncarpous, 1-loc., with 1 erect orthotropous ovule; style short with 2 stigmas. Flr. wind-fertilised; Juglans (q. v.) is chalazogamic. Fruit a drupe or nut. Testa thin; seed exalbuminous. *Chief genera:*

Pterocarya, Juglans, Carya. [Placed in Unisexuales by Benth.-Hooker, in Juglandiflorae by Warming.]

Juglandales. The 2nd cohort of Dicotyledons (Archichl.). See p. 127.

Juglandeae (Benth.-Hooker) = Juglandaceae.

Juglandiflorae (Warming). The 3rd cohort of Choripetalae. See p. 137.

Juglans Linn. Juglandaceae. 8 sp. N. temp. *J. regia* L. is the walnut. The ♂ flr. is 'adnate' to the bract and bracteoles and has 5, 4, 3, or 2 perianth leaves; the lowest flrs. have as many as 20 sta., the upper as few as 6. The fruit is a drupe, with a green fleshy exocarp, and a hard endocarp (the shell). The 'boats' into which the shell splits do not represent each a cpl.; the splitting is down the midribs of the cpls. Within is the seed with its thin brown seed-coat. It is exalbuminous with a basal radicle and two large cotyledons, which are rendered irregular in shape by the presence of partial septa in the ovary. The flr. of J. has lately been shown to be chalazogamic (Nawaschin in *Bot. Centr.* 63, 1895; see art. Chalazogamae).

The wood of the walnut is valued in cabinet-making, &c.; the seeds yield an oil. Many varieties are cultivated for their fruit.

Julocroton Mart. Euphorbiaceae (A. II. 1). 20 sp. trop. Am. Flrs. in spikes, the ♀ below, the ♂ above.

Juncaceae. Monocotyledons (Liliiflorae). 7 gen. with 200 sp. in damp and cold places, temp. and frigid zones. They have usually a creeping sympodial rhizome, one joint of the sympodium appearing above ground each year as a leafy shoot. The stem does not often lengthen out above ground, except to bear the infl. The leaves are usually narrow, and occasionally centric in structure (Juncus). Infl. usually a crowded mass of flrs. borne in cymes of various types, usually monochasial. Flr. ☿, regular, wind-fertilised. Perianth 3 + 3, sepaloid, with the odd leaf of the inner whorl posterior; sta. 3 + 3 (or the inner wanting), anthers dehiscing laterally, pollen in tetrads; cpls. (3), forming a sup. ovary; placentae axile or parietal, with ∞ or few anatropous ovules. Style simple, with 3 brush-like stigmas. Loculicidal capsule. Embryo straight, in starchy endosperm. *Chief genera:* Prionium, Juncus, Luzula. [Placed in Calycinae by Benth.-Hooker, in Glumiflorae by Warming.]

Juncaginaceae. Monocotyledons (Helobieae). 4 gen. with 10 sp., temp. Perennial marsh herbs of grass-like habit; in the axils of the sheathing leaves are 'squamulae intravaginales' (cf. Potamogetonaceae). Flrs. ☿, in racemes, regular, greenish, wind-fertilised, protogynous. P 3 + 3, A 3 + 3, anthers extrorse; $\underline{G}$ 3 + 3 sometimes united, but the outer whorl is often abortive; stigmas sessile; 1 anatropous ovule in each cpl. Achenes or schizocarp. Seed exalbuminous; embryo straight. *Chief genera:* Triglochin, Scheuchzeria, Lilaea. The order is joined to Naiadaceae by Benth.-Hooker.

Juncus (Tourn.) Linn. Juncaceae. 160 sp. cosmop. but chiefly in cold, wet places. 18 sp. of rush are found in Brit. Most sp. have a sympodial rhizome giving off one leafy shoot each year. The leaves are of various types, with large sheathing bases. Some are flat and grass-like, others needle-like, and still others centric in structure and standing erect. These last are chiefly found in the sp. inhabiting level plateaus in northern regions, where the light in summer comes from almost every direction in turn, and it has been suggested (see p. 181) that the erect position and centric structure is due to this; probably there is some correlation between the two phenomena. The infl. is a dense head or panicle, of cymose construction (usually rhipidia or drepania; see p. 64). In some sp. it appears to be lateral on a leaf-like cylindrical stem, but is really only pushed to one side by the bract of the infl. Flr. protogynous and wind-fertilised.

Rushes are largely used for making baskets, chair bottoms, &c. *J. squarrosus* L. is common on hill pastures in Brit.; it is eaten by sheep and forms a valuable part of their fodder when grass is scarce.

Juniperus Tourn. ex Linn. Coniferae (Arauc. 2 d; see C. for genus characters). 30 sp. N. Hemisp. The common Juniper, *J. communis* L. (Asia and Eur. incl. Britain), and *J. Oxycedrus* L., &c. have needle leaves throughout life; others, such as *J. Sabina* L., the Savin (Eur. As.), have small leaves closely appressed, as in Cupressus. Seedling forms of these are known (see Retinospora). The cone consists of 1—4 whorls of scales, one only being fertile, as a rule. In ripening the whole becomes a fleshy mass enclosing the hard seeds, and forming a good imitation of a true berry. The fruit is eaten by birds. That of *J. communis* is used in making gin. The wood of *J. virginiana* L. is the red cedar used for pencils.

Jurinea Cass. Compositae (XI). 50 sp. Medit., Eur., As.

Jussieua Linn. (Jussiaea). Onagraceae (I). 36 sp. trop.; water and marsh plants. Aerating tissue is well developed (cf. Sonneratia, Sesbania, and see p. 161). In *J. repens* L. (*J. diffusa* Forsk.), when growing in water, two forms of root develope, ordinary anchorage roots and erect spongy roots which grow upwards, often till they reach the surface of the water. The bulk of the tissue consists of aerenchyma. In *J. suffruticosa* L. (*J. salicifolia* H. B. et K.) there is an erect stem, whose lower part is covered with aerenchyma if growing in water (cf. Lycopus). If the plants be grown on land none of these phenomena appear. [Figs., &c. in Goebel's *Pflanzenbiol. Schild.* II. 256.]

Justicia Houst. ex Linn. Acanthaceae (IV. B). 250 sp. trop.

Kadsura Kaempf. Magnoliaceae (2). 7 sp. trop. As. and Japan. Flrs. unisexual, spiral throughout. Climbing shrubs with no stipules.

Kaempferia Linn. Zingiberaceae. 18 sp. trop. Afr., E. Ind.

Kalanchoë Adans. Crassulaceae. 55 sp. trop. Like Bryophyllum.

Kalmia Linn. Ericaceae (I. 3). 6 sp. N. Am. The anthers are held in pockets of the corolla, and thus, when the flr. is open, the filaments are bent like bows. An insect probing on the outer side of the filaments for honey, releases the anthers, which fly up, shooting the pollen out upon the under side of the visitor.

Karatas (Plum.) Mill. (incl. *Nidularium* Lam.). Bromeliaceae (1). 18 sp. W. Ind., Brazil.

Kaufmannia Regel. Primulaceae (1). 1 sp. Turkestan.

Kaulfussia Blume. Marattiaceae (II). 1 sp. S. E. As. The palmate leaf has large pores on the under side, due to the tearing apart of guard cells of stomata.

Kennedya Vent. (excl. *Hardenbergia* Benth.). Leguminosae (III. 10). 12 sp. Austr. The flrs. of some sp. are almost black.

Kentia Blume. Palmae (IV. 6). 10 sp. Moluccas to N. Z. (not in Austr.). Flrs. in groups of 3 (2 male) on the spadix.

Kernera Medic. = Cochlearia Linn. (5 sp. Alps.)

Kerria DC. Rosaceae (III. 5). 1 sp. E. As. *K. japonica* DC., often cultivated, especially in the double-flowered form.

Kibara Endl. Monimiaceae. 10 sp. E. Ind. to Austr.

Kickxia Blume. Apocynaceae (II. 4). 2 sp. trop. Afr., Java.

Kielmeyera Mart. Guttiferae. 17 sp. Campos of Brazil. [Ternstroemiaceae, Benth.-Hooker.]

Kigelia DC. Bignoniaceae (IV). 3 sp. trop. Afr., Madag. The infls. are borne on old wood (p. 42), hanging down on very long stalks.

Kingia R. Br. Liliaceae (III). 1 sp. W. Austr., a characteristic plant of the district. Placed in Juncaceae by Benth.-Hooker.

Kitaibelia Willd. Malvaceae (1). 1 sp. lower Danube.

Kleinia Linn. = Senecio Tourn.

Knappia Sm. = Mibora Adans.

Knautia Linn. = Scabiosa Tourn.

Kniphofia Moench. Liliaceae (III). 16 sp. S. Afr., often cultivated for their handsome spikes of flrs. Bees sometimes force their way into the flrs. and are unable to return.

Kobresia Willd. Cyperaceae (II). 4 sp. As., Eur. (1 Brit.).

Kochia Roth. Chenopodiaceae (5). 30 sp. cosmop.

Koeberlinia Zucc. Koeberliniaceae. 1 sp. Texas, Mexico. A leafless xerophyte with thorny twigs.

Koeberliniaceae. Dicotyledons (Archichl. Parietales). Only genus Koeberlinia (q. v.), placed in Simarubaceae by Benth.-Hooker. See *Nat. Pfl.*

Koeleria Pers. Gramineae (X). 15 sp. temp. (1 Brit.).

Koelreuteria Laxm. Sapindaceae (10). 2 sp. China. The capsule is large and bladdery and may be blown about by wind (cf. Colutea).

Koenigia Linn. = Polygonum Tourn.

Kohleria Regel = Isoloma Dcne.

Koniga R. Br. = Alyssum Tourn.

Korthalsia Blume. Palmae (III). 20 sp. E. Ind. Some, *e.g. K. horrida* Becc., are said to be myrmecophilous (cf. Cecropia), the ants living in the sheaths of the leaves.

Krameria Loefl. Leguminosae (II. 6). 13 sp. Mexico to Chili. It is placed in Polygalaceae by Benth.-Hooker, but has a petal, not a sepal, posterior. K and C 4—5; A 4, anthers opening by pores. See Eichler, *Blüthendiag.* p. 522.

Kraunhia Rafin. = Wistaria Nutt.

Krokeria Moench = Lotus Linn.

Krynitzkya Fisch. et Mey. Boraginaceae (IV. 2). 40 sp. W. Am.

Kuhnistera Lam. = Petalostemon Michx.

Kyllinga Rottb. Cyperaceae (II). 40 sp. trop.

Labiatae. Dicotyledons (Sympet. Tubiflorae). About 150 gen. with 2800 sp., cosmop. The chief centre is the Medit. region. Some of the small sub-orders are localised in their distribution, *e.g.* II. in Austr. and Tasmania, III. in India, Malaya, China, &c., VIII. in Centr. Am., whereas the large ones, such as I. and IV., are cosmop. Most L. are land-plants, and herbs or undershrubs, exhibiting much similarity in habit and structure. Stem usually square, with decussate simple exstip. leaves, often hairy and with epidermal glands secreting volatile oils, which give characteristic scents to many plants of the order. There are a few marsh-plants (Mentha, Lycopus, &c.), a few climbers (sp. of Stenogyne, Scutellaria, &c.), and a few small trees (Hyptis sp.). Many are xerophytes with reduced, sometimes infolded, leaves, hairiness, thick cuticles, &c., *e.g.* Rosmarinus.

The axis of the first order is not closed by a flr. but only those of later orders; thus the primary form of the infl. is racemose, and a simple raceme actually occurs in Scutellaria, &c. Usually however a dichasial cyme, becoming cincinnal in its later branchings (p. 64), occurs in the axil of each leaf upon the upper part of the main axis. In Teucrium, Nepeta sp., &c., the construction of this cyme is easily seen; but in most L. it is closely 'condensed' into the axil, so that all the flrs. are sessile; even here, however, it is easily seen that the central flr. opens first and then those on either side of it (see diagram). The two condensed cymes at each node overlap the leaf-axils and often form what looks like a whorl of flrs.; this infl. is often called a *verticillaster* or false whorl.

Floral diagram of Lamium album with indication of the dichasial double cincinnus at the sides. (After Eichler.) The asterisk represents the missing posterior sta.

Flr. ☿ or gynodiœcious, zygomorphic, hypogynous, 5-merous with suppression in some whorls. The common formula is K (5), C (5), A 4, G̲ (2). Calyx hypogynous, tubular, bell- or funnel-shaped, sometimes 2-lipped, persistent in fruit. Corolla usually 2-lipped with no clear indication of the individual petals. Sta. 4, didynamous, or of nearly equal length, sometimes 2, epipetalous with introrse anthers.

Ovary on a nectariferous disc (often developed on anterior side only), of (2) cpls. placed antero-posteriorly. Early in its development a constriction appears in the ovary in the antero-posterior line, dividing each cpl. into 2 loculi, so that the ovary becomes 4-loc. as it matures. Each of the 4 portions is nearly independent of the rest, and the style springs between them from the base of the ovary (*i.e.* is *gynobasic*); stigma 2-lobed. Placentae axile, each with 1 basal erect anatropous ovule with ventral raphe. The fruit is usually a group of 4 achenes or *nutlets*, each containing one seed; sometimes it is a drupe. Seed with no endosperm or very little; the radicle of the embryo points downwards (cf. Boraginaceae).

The flrs. of L. belong in general to the classes H. and F. (pp. 92, 91). The 2-lipped corolla ensures that the visiting insect shall take a definite position in regard to the anthers and stigma whilst probing for the honey at the base of the flr. The lower lip acts as a flag to attract insects, and also as a landing-place, whilst the upper lip shelters the essential organs, which are usually placed so as to touch the insect's back. The length of the corolla-tube varies very much, and with it the kind of visitors. Most Brit. sp. are bee flrs., the long-tubed red flrs. of Monarda &c. are butterfly flrs., and a few sp. of Salvia &c. are humming-bird flrs. (p. 99). The pollination-mechanism is usually simple; in Lamium, &c. the flr. is homogamous, the stigma merely projecting beyond the anthers so as to be touched first, but usually the flr. is dichogamous (protandrous), often with movements of the essential organs, *e.g.* in Teucrium, &c. The lever-mechanism of Salvia is almost unique. Thymus, Origanum, and their allies, have nearly regular flrs. visited by a more miscellaneous selection of insects. In many L., especially § VI., interesting distributions of sex appear, especially gynodiœcism (p. 68).

A few L. disperse their fruits by aid of the persistent bladdery calyx, which acts as a sail; a few have hooks formed from the calyx-teeth. The stalks are very often hygroscopic and move in such a way as to favour the dispersal of the fruits in wet weather (see Miss Pertz in *Nat. Science*, Oct. 1894).

The L. are useful on account of the volatile oils which they contain; many, *e.g.* Thymus, Ocimum, Origanum, Salvia, &c., are used as condiments. Oils and perfumes are obtained by distillation from Rosmarinus, Pogostemon, Lavandula, &c. Food-products are obtained from Stachys sp.

Classification and chief genera (after Briquet, from whose account much of the above is condensed): the L. are closely allied to Verbenaceae; from Boraginaceae the position of the radicle sharply separates them, whilst the similarity to Scrophulariaceae, &c. is largely in minor characters.

A. Style not gynobasic. Nutlets with lateral-ventral attachment and usually large surface of contact (often > $\frac{1}{2}$ as high as ovary).

I. *AJUGOIDEAE* (seed exalbuminous):

1. *Ajugeae* (corolla various; upper lip if present rarely concave; sta. 4 or 2; anther 2-loc.; nutlets ± wrinkled): Ajuga, Teucrium.
2. *Rosmarineae* (corolla strongly 2-lipped; upper lip very concave and arched; sta. 2; anthers 1-loc.; nutlets smooth): Rosmarinus (only genus).

II. *PROSTANTHEROIDEAE* (seed albuminous): Prostanthera.

B. Style perfectly gynobasic. Nutlets with basal attachment and usually small surface of contact, rarely with ± basal-dorsal attachment.

III. *PRASIOIDEAE* (nutlet drupaceous with fleshy or very thick exocarp and hard endocarp): Stenogyne, Gomphostemma.

IV. *SCUTELLARIOIDEAE* (nutlet dry; seed ± transversal; embryo with curved radicle lying on one cotyledon): Scutellaria.

V. *LAVANDULOIDEAE* (nutlet dry; seed erect; embryo with short straight superior radicle; disc-lobes opp. to ovary-lobes; nutlets with ± distinct dorsal-basal attachment; sta. 4 included; anthers 1-loc. at tip through union of thecae): Lavandula (only genus).

VI. *STACHYDOIDEAE* (ditto, but disc-lobes, when distinct, alt. with ovary-lobes; nut with small basal attachment; sta. ascending or spreading and projecting straight forwards):

1. *Marrubieae:* Marrubium, Sideritis.
2. *Perilomieae:* Perilomia (only genus).
3. *Nepeteae:* Nepeta, Dracocephalum.
4. *Stachydeae:* Prunella, Phlomis, Galeopsis, Lamium, Ballota, Stachys.
5. *Glechoneae:* Glechon.
6. *Salvieae:* Salvia.
7. *Meriandreae:* Meriandra.
8. *Monardeae:* Monarda, Ziziphora.
9. *Hormineae:* Horminum.
10. *Lepechinieae:* Lepechinia.
11. *Satureieae:* Calamintha, Satureia, Origanum, Thymus, Mentha.
12. *Pogostemoneae:* Pogostemon.

VII. *OCIMOIDEAE* (as VI., but sta. descending, lying upon under lip or enclosed by it): Hyptis, Ocimum.

VIII. *CATOPHERIOIDEAE* (nutlet dry; seed erect; embryo with curved radicle lying against the cotyledons): Catopheria.

[L. are placed in Lamiales by Benth.-Hooker, in Nuculiferae by Warming.]

Laburnum Linn. Leguminosae (III. 3). 3 sp. Eur., W. As., of which *L. vulgare* J. Presl. is the common laburnum of shrubberies. The flr. has a simple Trifolium-mechanism. There is no free honey; bees pierce the swelling at the base of the vexillum (cf. Orchis). All parts are poisonous.

Lachenalia Jacq. Liliaceae (V). 30 sp. S. Afr. *L. tricolor* Jacq. a pretty little bulbous plant with two leaves, is in cultivation.

Lachnanthes Ell. Haemodoraceae. 1 sp. *L. tinctoria* Ell., N. Am., the paint-root. The roots yield a red dye. See *Orig. of Species*, 6th ed., p. 9.

Lacistema Sw. Lacistemaceae. 16 sp. trop. Am.

Lacistemaceae. Dicotyledons (Archichl. Piperales). Only genus Lacistema. Closely allied to Piperaceae. See *Nat. Pfl.*

Lactoridaceae. Dicotyledons (Archichl. Ranales). An order composed of the single sp. *Lactoris fernandeziana* Phil. from Juan Fernandez (p. 148). See *Nat. Pfl.* Placed in Piperaceae by Benth.-Hooker.

Lactoris Phil. Lactoridaceae. See order.

Lactuca (Tourn.) Linn. (incl. *Mulgedium* Cass.). Compositae (XIII). 90 sp. chiefly N. temp. Old World; 4 in Brit. *L. Scariola* L., the prickly lettuce, is a compass-plant when growing in dry exposed places (see Silphium). *L. sativa* L. is the common lettuce used in salads. Its value depends on the latex. Flr. like Hieracium. The former is rapidly spreading in the U. S. as a weed (p. 141).

Ladenbergia Klotzsch (excl. *Cascarilla* Wedd.). Rubiaceae (I. 4). 10 sp. S. Am.

Laelia Lindl. Orchidaceae (13). 20 sp. trop. Am. Often epiphytic. Like Cattleya.

Lagenandra Dalz. Araceae (VII). 4 sp. Ceylon.

Lagenaria Ser. Cucurbitaceae (III). 1 sp. trop. Old World, *L. vulgaris* Ser., the calabash-cucumber. The outer woody pericarp of the fruit makes an excellent flask.

Lagerstroemia Linn. Lythraceae. 23 sp. Madag. to E. As. and Austr. Some are heterostyled like Lythrum.

Lagetta Juss. Thymelaeaceae. 3 sp. W. Ind. *L. Lintearia* Lam. is the lace tree. Its bast-fibres on removal from the stem (by maceration, &c.) form a network used for making dresses, &c.

Lagoecia Linn. Umbelliferae (3). 1 sp. Medit. One of the usual two loc. of the ovary is aborted.

Lagurus Linn. Gramineae (VIII). 1 sp. Medit., *L. ovatus* L., cultivated as an ornamental grass and for use in bouquets.

Lamarckia Moench. Gramineae (X). 1 sp. Medit.

Lamiales (Benth.-Hooker). The 10th cohort of Gamopetalae (p. 135).

Lamium (Tourn.) Linn. Labiatae (VI. 4). 40 sp. Eur., As., extratrop. Afr. 5 in Brit., of which the chief are *L. album* L. (white dead-nettle), *L. amplexicaule* L. (henbit), *L. purpureum* L. (purple dead-nettle) and *L. Galeobdolon* Crantz (yellow archangel). *L. album* has sympodial rhizomes and large white homogamous humble-bee flrs. *L. amplexicaule* has cleistogamic flrs. in spring and autumn; they look like ordinary buds with a small corolla, and are pollinated without opening (p. 98).

Lampsana (Tourn.) Rupp. = Lapsana Linn.

Landolphia Beauv. Apocynaceae (I. 1). 16 sp. trop. and S. Afr. Several are lianes with curious hook tendrils like those of Strychnos. The fruit is a large berry full of an acid pulp composed of the hair-structures on the seeds. Several sp., *e.g. L. Kirkii* Dyer, *L. comorensis* Benth. et Hook. f., &c., yield indian-rubber, the latex, coagulated, which exudes from a wound. It is known in trade as African rubber.

Langsdorffia Mart. Balanophoraceae. 1 sp. *L. hypogaea* Mart., trop. Am.

Lankesteria Lindl. Acanthaceae (IV. A). 4 sp. trop. W. Afr.

Lantana Linn. Verbenaceae (II). 50 sp. trop. and sub-trop. Shrubs, often used for making hedges. Some have edible fruit.

Lapageria Ruiz et Pav. Liliaceae (X). 1 sp. Chili, *L. rosea* Ruiz et Pav., a climbing shrub with handsome flrs. and edible fruit, often grown in greenhouses.

Lapeyrousia Pourr. Iridaceae (III). 22 sp. S. and trop. Afr.

Laportea Gaudich. Urticaceae (I). 25 sp. trop. Many sting violently.

Lappa (Tourn.) Rupp. = Arctium Linn.

Lapsana Linn. Compositae (XII). 9 sp. N. temp. Old World. *L. communis* L., the nipplewort, is common in Brit. The flrs. are inconspicuous and pollinate themselves regularly. There is no pappus.

Lardizabala Ruiz et Pav. Lardizabalaceae. 2 sp. Chili. A tough fibre is got from the stems of *L. biternata* Ruiz et Pav.

Lardizabalaceae. Dicotyledons (Archichl. Ranales). 7 gen. with 12 sp. Himal. to Japan, and Chili. Mostly climbing shrubs with palmate leaves. Flrs. in racemes, usually in the axils of the scale-leaves at the bases of the branches, polygamous or diclinous. The usual formula is P 3+3, A 3+3, $\underline{G}$ 3 or more. 2 whorls of small honey-leaves (see Ranunculaceae) often occur between perianth and sta. Sta. sometimes united; anthers extrorse. Ovules ∞ in longitudinal rows on the lateral walls (cf. Nymphaeaceae), anatropous. The flr. of either sex shows rudiments of the organs of the other sex. Fruit a berry. Embryo small and straight, in copious endosperm. *Chief genera:* Decaisnea, Akebia, Lardizabala. Benth.-Hooker unite L. to Berberidaceae, to which and to Menispermaceae they are closely allied. Warming places L. in Polycarpicae.

Larix Tourn. ex Adans. Coniferae (Arauc. 1 b; see C. for genus characters). 8 sp., five in Eur. and N. As., three in N. Am. The general characters are those of Cedrus, but the leaves are deciduous (p. 154), and the cones ripen in a single year. *L. europaea* DC. (*L. decidua* Mill.) is the common larch, cultivated on a large scale for its wood, bark (used in tanning) and turpentine (Venice t.). *L. pendula* Salisb. (*L. americana* Michx.) is a common N. Am. sp.

Larrea Cav. Zygophyllaceae. 4 sp. sub-trop. Am. Xerophytes. *L. mexicana* Moric. (Mexico, &c.) is the creosote plant, which forms a dense scrub-vegetation and binds the drifting sand together. Its strong smell prevents it from being eaten by animals.

Laserpitium Linn. Umbelliferae (9). 20 sp. Eur., N. Afr., As.

Lasiandra DC. = Tibouchina Aubl.

Lasianthera Beauv. Icacinaceae. 1 sp. trop. W. Afr. (Olacineae, Benth-Hooker).

Lasianthus Jack. Rubiaceae (II. 15). 80 sp. E. As., Indo-mal., N. Austr.

Lasiopetalum Sm. Sterculiaceae. 25 sp. Austr.

Lasthenia Cass. Compositae (VI). 5 sp. W. Am.

Lastrea Presl = Nephrodium Rich. (usually same spec. names).

Latania Comm. ex Juss. Palmae (II. 3). 3 sp. E. Afr., Mascarenes.

Lathraea Linn. Orobanchaceae. 5 sp. temp., Eur., As. *L. Squamaria* L. in Brit. (tooth-wort). This sp. is a curious parasite living upon the roots of hazel, beech, &c. It has a thick rhizome bearing 4 rows of tooth-like scaly leaves. The flowering shoot comes above ground and bears a raceme of purplish flrs. The flrs. are all bent round to the same side of the infl. (p. 66), and are protogynous. The scales upon the rhizome are curiously hollowed, each containing a branched cavity opening to the outside by a narrow slit at the base of the back of the leaf. This arises by a development similar to that which forms the chambers in the leaves of Empetrum, Cassiope, &c. In the small lateral cavities opening out of the main one there are found peculiar glandular organs, resembling those of insectivorous plants (p. 177). Some are of two cells, forming a small head, upon a one-celled stalk; others are sessile, of 2—4 cells. From the surface of both kinds radiate hyaline threads, whose nature has caused much discussion. Some affirm them to be protoplasmic, others of waxy or even bacterial nature. Small insects &c. are often found in these leaves (cf. bladders of Utricularia, &c.) and it has been supposed that these organs absorb their proteid materials after the manner of the glands of Drosera, &c. This however is very doubtful, but it is quite possible that the plant may absorb the products of their decay. It seems probable that L. is able to some extent to nourish itself saprophytically. Another common sp. in Eur. is *L. Clandestina* L., parasitic upon willows. The capsule of L. splits explosively. [For details see Heinricher in *Sitz. k. Akad. Wien*, CI. 1892, *Berichte D. Bot. Ges.* 1893, 1895, and *Cohn's Beitr.* VII. (reviewed in *Bot. Centr.* 65, p. 307).]

Lathyrus (Tourn.) Linn. (incl. *Orobus* Linn.). Leguminosae (III. 9). 100 sp. N. temp., and Mts. of trop. Afr. and S. Am. 10 sp. in Brit. (pea), including *L. Aphaca* L. and *L. Nissolia* L. The former has large green stipules performing assimilatory functions, whilst the leaf is transformed into a tendril; the latter has its petioles flattened into phyllodes and has no leaf blade at all (see Acacia). *L. macrorrhizus* Wimm. has tuberous roots which may be eaten like potatoes. *L. sativus* L. (Jarosse) and *L. Cicera* L. are cultivated in S. Eur. as fodder and are also eaten like chick-pea (Cicer). *L. odoratus* L. is the sweet-pea. The flr. is like that of Vicia; on the style is a tuft of hairs that brushes the pollen out of the apex of the keel, where it is shed by the anthers.

Lauraceae. Dicotyledons (Archichl. Ranales). 40 gen. with 1000 sp. trop. and sub-trop.; the chief centres of distribution are S.E. As. and Brazil. Trees and shrubs with leathery evergreen alt. exstip. leaves. The tissues contain numerous oil-cavities. Cassytha is an interesting parasite. Infl. racemose, cymose, or mixed. Flr. actinomorphic, apetalous, usually 3-merous, ☿ or monœcious. The formula is usually P_{2n}, A_{4n}, $\underline{G}_n$. Perianth in two whorls, perigynous. Sta. perigynous or epigynous, in 3 or 4 whorls, some of which are commonly reduced to staminodes; anther usually 4-loc. opening by valves (cf. Berberidaceae). The anthers are usually introrse, but in many cases those of the third whorl are extrorse. The axis is more or less concave, and the ovary is free from it at the sides. Cpls. 1 (Payer, Baillon) or more probably 3 (Eichler), forming a 1-loc. ovary, with 1 pendulous anatropous ovule. Fruit a berry, often more or less enclosed by the cup-like receptacle, which also becomes fleshy in these cases. Embryo straight; seed exalbuminous. The position of the L. in the system is doubtful; they apparently form the connecting link between the Ranales (to the more typical families of which they are linked by Monimiaceae and Calycanthaceae) and the Thymelaeales. They are placed in Daphnales by Benth.-Hooker, in Polycarpicae by Warming. Important economic plants are found in nearly all the genera mentioned below. [See *Nat. Pfl.* and Mez in *Bot. Jahresb.* 1889, p. 459, and *Bot. Centr.* 54, p. 275 (abstracts).]

Classification and chief genera (after Pax):

I. *PERSOIDEAE* (anther 4-loc.): Cinnamomum, Persea, Sassafras, Litsea.

II. *LAUROIDEAE* (anther 2-loc.): Cryptocarya, Lindera, Laurus, Cassytha.

Laurelia Juss. Monimiaceae. 1 sp. N.Z., 1 sp. Chili. The former, *L. Novae-Zelandiae* A. Cunn., supplies a useful timber. The fruits of the latter, *L. aromatica* Juss., are used as a spice under the name of Peruvian nutmegs.

Laurus (Tourn.) Linn. Lauraceae (II). 2 sp., *L. nobilis* L. the true Laurel or Sweet Bay, Medit., and *L. canariensis* Webb et Berth., Canaries and Madeira. The leaves of the Bay are aromatic and are used in condiments &c.; the berries are employed in veterinary medicine. Flrs. unisexual by abortion.

Lavandula Tourn. ex Linn. Labiatae (V, q.v. for genus characters). 20 sp. Medit. region, from Canaries to India. *L. vera* DC. is the common lavender. From it is obtained oil of lavender, by distillation of the flrs. The oil is used in painting, &c., and in the manufacture of lavender water. *L. Spica* Cav. and *L. Stoechas* L. are also used. The protandrous flrs. are visited by bees and form a good source of honey.

Lavatera Linn. Malvaceae (II). 20 sp. chiefly Medit.; 2 in Canaries, 1 Austr., 1 mid-As. *L. arborea* L., tree-mallow, on rocks on the Brit. coast.

Lavoisiera DC. Melastomaceae (I). 50 sp. Brazil.

Lawsonia Linn. Lythraceae. *L. inermis* L., the only sp., everywhere cultivated in the tropics, originally E. Afr. to N. Austr. The powdered leaves form the well-known cosmetic, *henna*, used in the East to stain the finger-nails, &c. red.

Layia Hook. et Arn. Compositae (V). 14 sp. west N. Am.

Leandra Raddi. Melastomaceae (I). 200 sp. trop. Am.

Lebeckia Thunb. Leguminosae (III. 3). 24 sp. S. Afr.

Lecanopteris Blume. Polypodiaceae. 1 sp. Indo-mal., often placed in Polypodium.

Lechea Kalm. Cistaceae. 4 sp. Am.

Lecythidaceae. Dicotyledons (Archichl. Myrtiflorae). 18 gen. with 220 sp. of trop. trees. The leaves are generally in bunches at the ends of the twigs, simple, exstipulate. Flrs. single or in racemose infls., ☿, perigynous or epigynous, with complete fusion of receptacle and ovary. K 4—6, C 4—6, A ∞ in several whorls, the sta. more or less united at base. Ovary with 2—6 or more loc., in each 1—∞ anatropous ovules. There is usually an intra-staminal disc as well as one under petals and sta. Berry or capsule. No endosperm. Bertholletia and others are economic plants. *Chief genera:* Barringtonia, Napoleona, Couroupita, Lecythis, Bertholletia. United to Myrtaceae by Benth.-Hooker and Warming.

Lecythis Loefl. Lecythidaceae. 30 sp. trop. S. Am. The fruit is a huge wooden capsule, opening by a lid. The oily seeds are eaten as Sapucaia nuts. The empty fruit is termed a 'monkey-pot' from its use in catching monkeys. It is filled with sugar, the monkey inserts its hand, clasps it, and then cannot withdraw it.

Ledum Rupp. ex Linn. Ericaceae (I. 1). 3 sp., two in N. Am., *L. palustre* L. circumpolar. The leaves are rolled back (cf. Empetrum). This sp. is used in Labrador as tea. Seeds winged at ends.

Leea Royen. Vitaceae (II). 45 sp. trop. Old World.

Leersia Soland. ex Sw. Gramineae (VI). 5 sp. N. temp. and trop. Marsh grasses similar to Oryza, and used as fodder in As. *L. oryzoides* Sw. (Eur.) has cleistogamic flrs. (Darwin, *Forms of Flrs.*, p. 335).

Leguminosae. Dicotyledons (Archichl. Rosales). The second largest family of flowering plants, with about 440 gen. and 7000 sp., cosmop. Mimosoideae and Caesalpinioideae are mostly trop., Papilionatae mostly temp. (abundant on steppes, &c.). The account here given is largely condensed from that of Taubert in *Nat. Pfl.*

Living in every kind of soil and climate, the L. show great variety in habit—trees, shrubs, herbs, water-plants, xerophytes, climbers, &c. The roots of most sp. exhibit peculiar *tubercles*—metamorphosed lateral roots containing the peculiar bacterial organisms (Rhizobium sp.) about which there has been so much discussion in late years. Plants provided with these are able to take up much more atmospheric nitrogen than those not so provided. The plant appears actually to consume the 'bacteroids' which live in its cells, after they have stored up in themselves a considerable amount of nitrogenous material. Hence the great value of the L. as a crop on poor soil, or as preceding wheat in the rotation of crops; for instead of impoverishing the soil they rather enrich it, either by the nitrogen contained in their roots and liberated as these decay, or by that of the whole plant if ploughed in as 'green manure.'

The stem is commonly erect, but many climbers occur. Some, *e.g.* Vicia, climb by leaf-tendrils, some, *e.g.* Bauhinia, by stem-tendrils, some by hooks (modified leaves in Caesalpinia, &c., emergences in Acacia, &c.), some by twining, and so on. Creeping stems, rooting at the nodes, also occur. Thorns, usually modified branches (*e.g.* Gleditschia) or stipules (*e.g.* Acacia), are common. The stems of the erect trop. sp. often branch in such a way that the branches run parallel and erect, and bear crowns of leaves at the top (p. 155). The stems of many lianes are peculiarly shaped, often flat, or corrugated in various ways, owing to peculiar methods of growth in thickness.

The leaves are usually alt., stipulate, and nearly always compound. Many sp. have very small leaves, *e.g.* Ulex, or scaly leaves and flat stems, *e.g.* Carmichaelia. The stipules vary much in size &c. (see Acacia, Lathyrus, Vicia). The leaves usually perform sleep-movements (p. 49) at night; the direction of motion varies, some moving upwards, some downwards, or in other ways, but the final result is usually to place the leaflet edgewise to the sky. In Mimosa and Neptunia the leaves are sensitive to a touch and at once assume the sleep-position, recovering after a time. In *Desmodium gyrans* the lateral leaflets execute continuous spontaneous movements as long as the temperature is high enough.

The infl. is apparently always racemose, but with much variety. The simple raceme is very common, also the panicle and spike. Dorsiventral racemes, resembling the cymes of Boraginaceae, also occur (*e.g.* Dalbergia). The flrs. are regular (and then frequently polygamous) or irregular (and then usually ☿). The receptacle is usually convex or flat, so that at most the flr. is slightly perigynous. The calyx developes in ascending order and is usually 5-merous, the odd (oldest) sepal being anterior. The sepals are more or less united.

The corolla is polypetalous, alternating with the calyx; its aestivation may be valvate (Mimosoideae), ascending imbricate (Caesalpinioi deae), or descending (Papilionatae). In many cases it is zygomorphic to a high degree, having a large petal posterior (vexillum or standard),

Floral diagrams of *Vicia Faba* (Papilionatae) and *Acacia latifolia* (Mimosoideae), after Eichler (modified).

two lateral (alae or wings), and two anterior more or less joined to form a keel or carina. The andrœceum consists typically of 10 sta., free or united into a tube; in the latter case the tenth sta. (the posterior one) often remains free, so as to leave a slit in the tube, only covered loosely by this sta. Many variations from the typical andrœceum are found. In cases where a keel is present, the sta. are enclosed in it.

The gynœceum consists typically of one cpl. with its ventral side directly posterior; it has a long style and terminal stigma. There are two rows of ovules (they alternate with one another so as to stand in one vertical rank), anatropous or amphitropous, ascending or pendulous.

Fertilisation. Only the Papilionatae have as yet been at all thoroughly studied (and only the European genera of these). The keel encloses the essential organs, protecting them from rain, &c. and rendering the flr. so complex that only the cleverer insects can make much of it. Honey is secreted by the inner sides of the sta. near their base, and accumulates in the stamen-tube round the base of the ovary. In order to render the honey accessible, the tenth sta. is free of the tube, and at the base, on either side of it, are two openings leading to the honey. The honey is thus concealed and at some depth, so that a clever insect with a tongue of moderate length is required. All this points to the P. being bee-flowers, as in fact is the case. Insects visiting the flrs. alight upon the wings and depress them by their weight, whilst they probe for honey under the standard. The wings are always joined to the keel, usually by a protuberance in the former fitting into a suitable hollow in the latter, so that the keel is thus depressed likewise. This causes the emergence of the essential organs, the stigma usually coming first, so that a fair chance of cross-fertilisation exists. Self-pollination usually occurs when the insect flies off, leaving the keel to return to its former position.

"Four different types of structure may be distinguished (in Papilionatae) according to the manner in which the pollen is applied to the bee: (1) P. in which the sta. and stigma emerge from the carina and again return within it. They admit repeated visits; *e.g.* Trifolium, Onobrychis. (2) P. whose essential organs are confined under tension and explode. In these only one insect's visit is effective; *e.g.* Medicago, Genista, Ulex. (3) P. with a piston mechanism which squeezes the pollen in small quantities out of the apex of the carina, and not only permits but requires numerous insect visits; *e.g.* Lotus, Ononis, Lupinus. (4) P. with a brush of hairs upon the style which sweeps the pollen in small portions out of the apex of the carina. They for the most part require repeated insect visits; *e.g.* Lathyrus, Vicia." (Müller.) Cleistogamy is fairly common in the order. In several cases the stigma in the unvisited flr. lies in the keel among the pollen, but it has been shown that it only becomes receptive (if young) when rubbed, so that autogamy does not necessarily occur in these cases. The first visitor will rub the stigma and autogamy will of course occur then, but if there were any other pollen on the insect, a cross will happen. For the peculiar phenomenon of *enantiostyly* (right- and left-styled flrs.) see Cassia. Some sp. have flrs. which after fertilisation bury themselves in the earth and there ripen their fruit; *e.g.* Arachis, Voandzeia, Trifolium, Vicia, Lathyrus, &c.

The fruit of the L. is typically a *legume* or pod opening by both sutures. In some the pod is constricted between the seeds, forming a *lomentum* which breaks up into indehiscent one-seeded portions. The pods frequently open explosively, the valves twisting up spirally, *e.g.* in Ulex, Cytisus sp., &c. In Colutea, &c. the pods are inflated and so catch the wind. Others are winged. Some are eaten by animals, but the seed-coats are hard enough to preserve the seeds from injury. Some have a coloured fleshy aril (Acacia sp., &c.). Still others have hooked pods, *e.g.* Medicago, Mimosa. [See Buchwald in Engler's *Bot. Jahrb.* XIX. 1894.]

The seed is exalbuminous and contains as a rule a very large store of reserve-materials in the cotyledons. This is of great importance to the young plant (p. 112), and in this respect the L. are better provided than most other families.

Economically the L. is a most important order. The seeds of many sp. form important food-stuffs, *e.g.* of Arachis, Cajanus, Cicer, Dolichos, Glycine, Lathyrus, Lens, Lotus, Lupinus, Phaseolus, Pisum, Vicia, Voandzeia, &c. The pods of Ceratonia, Tamarindus, Phaseolus, Prosopis, &c. are also eaten. A great number are valuable as fodder plants, *e.g.* Trifolium, Medicago, Onobrychis, Lotus, Vicia, &c. Many tropical sp. yield valuable timber; Crotalaria and others are sources of fibre; Haematoxylon, Genista, Indigofera, Acacia, &c. yield dyes; gums and resins are obtained from Acacia, Copaifera, Astragalus, Hymenaea, &c.; oil is expressed from the seeds of Arachis and Voandzeia; kino is obtained from Pterocarpus, and so on. See Chap. IV. and genera.

Classification and chief genera (after Taubert): the L. are nearly related to Rosaceae (especially Chrysobalaneae) and Connaraceae. Benth.-Hooker place them in Rosales, Warming erects L. into a separate cohort, and considers each of the three chief sub-orders as an independent order.

The primary division is:

I. *MIMOSOIDEAE*. Flrs. regular, corolla valvate.

II. *CAESALPINIOIDEAE*. Zygomorphic; corolla-aestivation imbricate ascending.

III. *PAPILIONATAE*. Zygomorphic papilionaceous; corolla-aestivation imbricate descending.

These are again subdivided: the following key enables one to ascertain to which of the subdivisions any Leguminous plant belongs.

I. *MIMOSOIDEAE*.

A. Calyx valvate.
  a. Sta. more than 10.
    1. *Ingeae* (sta. united): Inga, Calliandra.
    2. *Acacieae* (sta. free): Acacia (only gen.).
  b. Sta. twice as many as petals.
    3. *Eumimoseae* (anther glandless): Mimosa.
    4. *Adenanthereae* (anther in bud crowned by a gland; endosperm): Neptunia, Prosopis.
    5. *Piptadenieae* (ditto, no endosperm): Piptadenia.
B. Calyx imbricate.
    6. *Parkieae:* Parkia.

II. *CAESALPINIOIDEAE*.

A. Calyx in bud quite undivided or tubular below.
  a. Leaves simple or one pair of leaflets. Sta. 10 or fewer.
    4. *Bauhinieae:* Bauhinia, Cercis.
  b. Leaves once pinnate (exceptions). Sta. ∞ or rarely 9—13.
    9. *Tounateae:* Tounatea.
  c. Leaves bipinnate, or once pinnate; sta. 5.
    1. *Dimorphandreae:* Dimorphandra.
B. Calyx in bud quite polysepalous or very nearly so.
  a. Two anterior petals modified to large glands, anthers opening by pores.
    6. *Kramerieae:* Krameria.
  b. Two anterior petals developed or not, but not glandular.
   α. Leaves some or all bipinnate.
    7. *Eucaesalpinicae:* Caesalpinia, Haëmatoxylon, Gleditschia.

β. Leaves once pinnate.
5. *Cassieae* (anthers basifixed, opening by terminal pores): Cassia, Ceratonia.
3. *Amherstieae* (dorsifixed, no pores; ovary adnate behind to torus): Hymenaea, Tamarindus.
8. *Sclerolobieae* (ovary free, ovules more than 3).
2. *Cynometreae* (ovules 1 or 2): Copaiba.

III. *PAPILIONATAE.*

A. Sta. free.
1. *Sophoreae* (pinnate leaf): Sophora, Toluifera.
2. *Podalyrieae* (simple or palmate): Anagyris.

B. Sta. united.

a. Lomentum.
7. *Hedysareae:* Coronilla, Onobrychis, Arachis, Desmodium.

b. Legume or indehiscent pod.
α. Leaves absent.
6. *Galegeae:* Amorpha, Robinia, Colutea.
β. Leaves present.
I. *Leaf or leaflets without stipels.*
(1) Lf. simple or palmate.
* Lf. with 3 entire leaflets.
3. *Genisteae:* (shrubs) Genista, Lupinus, Ulex, Cytisus.
6. *Galegeae:* (herbs) as above.
** Lf. with 5 entire leaflets.
5. *Loteae:* Anthyllis, Lotus.
*** Lf. with 3 toothed leaflets.
4. *Trifolieae:* Ononis, Medicago, Trifolium.
(2) Leaf pinnate.
* Leaf-stalk ending in bristle or tendril.
9. *Vicieae:* Abrus, Vicia, Lathyrus.
** Leaf-stalk not ending so.
† Pod dehiscing in 2 valves.
§ Sta. filamentous.
10. *Phaseoleae:* (ovary surrounded by disc) Apios, Phaseolus.
6. *Galegeae:* (no disc) as before.
§§ Some or all sta. broadened at apex.
5. *Loteae:* as before.
†† Pod indehiscent.
8. *Dalbergieae:* Dalbergia, Pterocarpus.
II. *Leaves or leaflets with stipels.*
10. *Phaseoleae:* (pod dehiscent) as before.
8. *Dalbergieae:* (pod indehiscent) as before.

Leitneria Chapm. Leitneriaceae. 2 sp. N. Am.

Leitneriaceae. Dicotyledons (Archichl. Juglandales). Only genus

Leitneria. Shrubs with spikes of diœcious flrs. ♂ flr. naked with 3—12 sta. ♀ with scaly perianth and 1 cpl. and long style. Ovary 1-loc., with 1 amphitropous ovule. Fruit drupaceous. Seed albuminous. Embryo straight. Placed in Unisexuales by Benth.-Hooker.

Leitnerieae (Benth.-Hooker) = Leitneriaceae.

Lemna Linn. Lemnaceae. 6 sp. cosmop.; 4 in Brit. (duckweed). The plant consists in most sp., *e.g. L. minor* L., of a flat green blade, floating upon the water; this is the stem, which performs leaf-functions. From the under side hangs down a long adventitious root, with a well-marked root-cap. There are no leaves. The stems are oval and slightly turned up at the ends, so that if two are placed near together in water, they will run against one another and adhere by the tips. In the posterior portion on either side is a groove under the edge. In this arise branches which may either (as in *L. trisulca* L., &c.) remain in union with the parent shoot, or become detached and give rise to new plants. In autumn a number of these are formed ready to start growth in the next spring, whilst the mother plants sink to the bottom. The flrs. are also borne in these grooves. There is a very reduced spathe, with 2 male flrs. (each reduced to 1 sta.) and 1 female (1 cpl.).

Lemnaceae. Monocotyledons (Spathiflorae). 3 gen. with 18 sp. of free-swimming perennial water-plants with no leaves. The description of Lemna applies to the other genera also. Flrs. unisexual, monœcious; ♂ of 1 sta., ♀ of 1 cpl., with 1—6 basal, erect, ortho- to ana-tropous ovules. The micropylar end of the inner integument forms a kind of lid upon the seed. Endosperm slight. The L. are regarded as very reduced Araceae (q.v.). Benth.-Hooker place them in Nudiflorae, Warming in Spadiciflorae. *Genera:* Spirodela, Lemna, Wolffia. See *Nat. Pfl.* for full details.

Lennoaceae. Dicotyledons (Sympet. Ericales). A small order (3 gen. 5 sp.) of S. Californian and Mexican plants, parasitic by their roots on roots of Clematis, &c. For details see Drude in *Nat. Pfl. Genera:* Pholisma, Ammobroma, Lennoa.

Lens (Tourn.) Linn. Leguminosae (III. 9). 6 sp. Medit., W. As. *L. esculenta* Moench (*Ervum Lens* L.) is the lentil, a food-plant of great antiquity. The seeds furnish a flour which is often sold at high prices as food for infants &c. under fancy names.

Lentibulariaceae. Dicotyledons (Sympet. Tubiflorae). 5 gen. with 250 sp. cosmop. All belong to the group of insectivorous plants and show many interesting features in their vegetative organs; for details see p. 177 and genera. The infl. is usually a raceme or spike; flrs. solitary in Pinguicula &c. Flr. ☿, zygomorphic, 5-merous. K 2—5-lobed, the odd sepal posterior, often 2-lipped, persistent on the fruit; C (5), 2-lipped, the lower lip more or less spurred; A 2 (the anterior pair), epipetalous, with 1-loc. anthers; $\underline{G}$ (2) 1-loc. with free-central placenta and sessile 2-lobed stigma (the posterior lobe abortive);

ovules ∞ or 2, anatropous, often more or less sunk in the placenta. Capsule with ∞ seeds, opening by 2—4 valves, or with 1 seed indehiscent. Seed exalbuminous. *Genera:* Pinguicula, Genlisea, Polypompholyx, Utricularia, Biovularia. Placed in Personales by Benth.-Hooker, in Personatae by Warming. [See *Nat. Pfl.* and literature of Insectivorous plants (p. 177) for details.]

Leonotis R. Br. Labiatae (VI. 4). 12 sp. trop. and S. Afr.

Leontice Linn. Berberidaceae. 12 sp. N. temp. The base of the stem is tuberous.

Leontodon Linn. (incl. *Thrincia* Roth). Compositae (XIII). 45 sp. temp., Eur., As.; 3 in Brit. (hawkbit). Very like Taraxacum. In *L. hirtus* L. the outer fruits have no pappus.

Leontopodium R. Br. Compositae (IV). 4 sp. Mts. of Eur., As. and S. Am. *L. alpinum* Cass. is the Edelweiss. It is a xerophyte growing in dense tufts, and covered with woolly hairs. The heads of flrs. are small, but are massed together and surrounded by hairy bracts which add to their conspicuousness. The central florets are male, the style remaining, however, to act as pollen-presenter, though it has no stigmas. The outer florets are female.

Leonurus Linn. Labiatae (VI. 4). 8 sp. Eur., As., and trop. *L. Cardiaca* L. in Brit. (mother-wort).

Leopoldinia Mart. Palmae (IV. 6). 4 sp. trop. Brazil. *L. Piassaba* Wallace yields the best Piassaba fibre (Wallace, *Amazon*, ch. IX.).

Lepachys Rafin. Compositae (V). 4 sp. N. Am. Included in Rudbeckia in *Nat. Pfl.*

Lepidium Linn. Cruciferae (II. 5). 100 sp. cosmop. 5 in Brit. (cress). *L. sativum* L. (Orient) is the garden cress.

Lepidocaryum Mart. Palmae (III. 4). 5 sp. Brazil.

Lepidosperma Labill. Cyperaceae (II). 40 sp. Austr., N. Z., trop. As. *L. gladiatum* Labill. is the sword-sedge, used to bind sand-dunes in Austr., and as a material for paper-making.

Lepigonum Wahlb. = Spergularia J. et C. Presl.

Lepironia Rich. Cyperaceae (II). 1 sp., *L. mucronata* Rich., Madag., trop. As., Austr., Polynes., largely cultivated in China. The stems are beaten flat and woven into mats, sails (for junks), &c.

Leptospermum Forst. Myrtaceae (2). 25 sp. Malaya, Austr., N. Z.

Leptosporangiatae (Filicineae). See Filicineae Leptosporangiatae.

Leptotes Lindl. = Tetramicra Lindl.

Leschenaultia R. Br. Goodeniaceae. 16 sp. Austr. "In *L. formosa* R. Br., the insect's proboscis comes in contact with the lower lip of the pollen-cup (see order), thus opening it and dusting itself with pollen; in the next flower it places this pollen on the stigmatic surface which lies outside the pollen-cup." (Müller.)

Lespedeza Michx. Leguminosae (III. 7). 33 sp. temp. N. Am., As., and in Mts. of trop. As., Austr. The flrs. are sometimes apetalous, and cleistogamic. *L. striata* Hook. et Arn., an Asiatic sp., is being spread over N. Am. very rapidly by animal agency (p. 141). It is a useful fodder-plant.

Lesquerella Wats. = Vesicaria Tourn.

Lessertia DC. Leguminosae (III. 6). 40 sp. Afr.

Leucadendron Berg. Proteaceae (I). 70 sp. S. Afr. *L. argenteum* R. Br., the silver-tree, is well known; its leaves are covered with fine silky hairs, and may even be used for painting upon. It has been nearly extirpated by being largely used for firewood. Flr. like that of Protea. The perianth, when the fruit is ripe, splits into 4 segments, united together round the stigma, and acts as a wing for the fruit.

Leucanthemum (Tourn.) Linn. = Chrysanthemum Tourn.

Leucas Burm. Labiatae (VI. 4). 60 sp. trop., Afr., As.

Leuceria Lag. Compositae (XII). 50 sp. S. Am. Xerophytes.

Leuchtenbergia Fisch. et Hook. Cactaceae (I). 1 sp. Mexico. See order.

Leucocoryne Lindl. Liliaceae (IV). 3 sp. Chili.

Leucojum Linn. Amaryllidaceae (I). 10 sp. S. Eur. (snow-flake).

Leucopogon R. Br. Epacridaceae. 130 sp. Austr., Malaya. Included in Styphelia Sol. in *Nat. Pfl.*

Leucospermum R. Br. Proteaceae (I). 20 sp. Afr.

Leucothoë D. Don. Ericaceae (II. 4). 32 sp. Am. Like Andromeda.

Levenhookia R. Br. Candolleaceae. 7 sp. Austr. The labellum is shoe-shaped and at first embraces the column, but if touched it springs downwards.

Levisticum Riv. ex Linn. Umbelliferae (6). 1 sp. Eur.

Lewisia Pursh. Portulacaceae. 2 sp. California. *L. rediviva* Pursh (bitter-root) with its thick rhizome, fleshy roots and leaves, is one of the most xerophytic plants known. Two years' drying will hardly kill it. K 4—8, C 8—16; sta. numerous.

Leycesteria Wall. Caprifoliaceae (IV). 3 sp. Himalaya.

Liabum Adans. Compositae (VIII). 40 sp. Am. and W. Ind.

Liatris Schreb. Compositae (II). 15 sp. N. Am.

Libertia Spreng. Iridaceae (II). 8 sp. Chili, Austr., N. Z.

Libocedrus Endl. Coniferae (Arauc. 2 b; see C. for genus characters). 8 sp., 2 in Chili, 2 in N. Z., 1 each in New Caled., Japan, China, Calif. *L. Doniana* Endl. (N. Z.), *L. tetragona* Endl. (Chili) and *L. decurrens* Torr. (Calif.—the white cedar) yield valuable timber.

Licania Aubl. Rosaceae (VI. 13). 36 sp. S. Am.

Licuala Thunb. Palmae (I. 2). 36 sp. Indo-mal.

Ligularia Cass. = Senecio Tourn.

Ligusticum Linn. Umbelliferae (6). 25 sp. N. Hemisph. *L. scoticum* L. (lovage) occurs in Brit.; it is sometimes used as a pot-herb.

Ligustrum (Tourn.) Linn. Oleaceae (I. 3). 35 sp., esp. E. As. In Eur. (incl. Brit.) *L. vulgare* L., the privet, is common.

Liliaceae. Monocotyledons (Liliiflorae). One of the largest families of flowering plants; 200 gen. with 2500 sp., cosmop. The smaller groups of the order are often confined to definite floral regions. Most are herbs with sympodial rhizomes or bulbs; a few trop. and warm temp. forms, *e.g.* Yucca, Dracaena, &c., are shrubs or trees, often with an unusual mode of growth in thickness of the stem. Many are xerophytes; some, *e.g.* Aloe and Gasteria, are succulent; others, *e.g.* Phormium, have hard isobilateral leaves; others, *e.g.* Dasylirion, have tuberous stems and narrow leaves with reduced transpiration; Bowiea only produces leafy shoots in the wet season, and so on. Smilax, Gloriosa, &c. are climbing plants, the former with peculiar stipular tendrils. Ruscus exhibits phylloclades.

The infl. is most commonly of racemose construction, and the flrs. have no bracteoles; when the latter occur, the further branching from their axils usually takes a cymose form, especially that of a bostryx (p. 65), as *e.g.* in Hemerocallis. The apparent umbels or heads of Allium, Agapanthus, &c. are really cymose (p. 65). Solitary terminal flrs. occur in tulip, &c. The flrs. are usually ☿, regular, pentacyclic, 3-merous (rarely 2, 4, or 5), hypogynous. P 3 + 3, free or united, petaloid or sometimes sepaloid; A 3 + 3 or fewer, rarely more, usually with introrse anthers; G (3) usually superior, rarely inferior or semi-inferior, 3-loc. with axile, or rarely 1-loc. with parietal placentae; ovules usually ∞, in two rows in each loc., anatropous. Fruit usually capsular, loculicidal or septicidal, sometimes a berry. Seed with straight or curved embryo, in abundant fleshy or cartilaginous, never floury, endosperm.

The flrs. are usually insect-pollinated. Honey is often (*e.g.* in Scilla, Allium, &c.) secreted by glands in the ovary-wall between the cpls.; in other cases by glands on the bases of the perianth-leaves (see Müller's *Fert. of Flrs.* and *Alpenblumen* for general account of L.). Yucca (q.v.) has a unique pollination-method. The seed-dispersal mechanisms, with the exception of the few cases of fleshy fruits, are of low type.

Economically the L. are of no great value. The chief food plants are Allium and Asparagus; Phormium, Yucca, and Sansevieria yield useful fibre; Smilax, Urginea, Aloe, Colchicum, Veratrum, &c., are medicinal. Xanthorrhoea and Dracaena yield resins; Chlorogalum is used as soap. Many are favourite garden and greenhouse plants, *e.g.* Convallaria, Tulipa, Fritillaria, Lilium, Agapanthus, Kniphofia, Funkia, Hyacinthus, Gloriosa, and many more.

Classification and chief genera (after Engler): the L. are closely allied to Juncaceae; usually they can be distinguished by their petaloid perianth, that of J. being sepaloid, but many L. have a sepaloid perianth, *e.g.* Xanthorrhoea, Kingia, &c., and in these cases almost the only distinction is the absence in L. of the long thread-like twisted stigmas of J. Benth.-Hooker unite the genera mentioned, and some others, to Juncaceae, and they place sub-orders VIII and IX in Haemodoraceae. Warming splits up the family into Colchicaceae, Liliaceae, and Convallariaceae.

I. *MELANTHIOIDEAE* (rhizome, or bulb covered with scale-leaves and with terminal infl.; anthers extrorse or introrse; capsule loculicidal or septicidal; fruit never a berry): Tofieldia, Narthecium, Veratrum, Gloriosa, Colchicum.

II. *HERRERIOIDEAE* (tuber, giving off climbing stem; leaves in tufts; small-flowered racemes at the base of these or in panicles at ends of twigs; septicidal capsule): Herreria (only genus).

III. *ASPHODELOIDEAE* (rhizome with radical leaves, rarely stem with crown of leaves or leafy branched stem or bulb; infl. usually terminal, a simple or compound raceme or spike; P or (P); anthers introrse; capsule, rarely berry): Asphodelus, Chlorogalum, Bowiea, Funkia, Hemerocallis, Phormium, Kniphofia, Aloe, Gasteria, Haworthia, Aphyllanthes, Lomandra, Xanthorrhœa, Kingia.

IV. *ALLIOIDEAE* (bulb or short rhizome; cymose umbel $\pm$ enclosed by two broad or rarely narrow leaves, sometimes joined; infl. rarely of 1 flr.): Agapanthus, Gagea, Allium, Brodiaea.

V. *LILIOIDEAE* (bulb; infl. terminal, racemose; P or (P); anthers introrse; capsule loculicidal, except in Calochortus): Lilium, Fritillaria, Tulipa, Urginea, Galtonia, Scilla, Ornithogalum, Hyacinthus, Muscari.

VI. *DRACAENOIDEAE* (stem erect with leafy crown, except in Astelia; leaves sometimes leathery, never fleshy; P free or united at base; anthers introrse; berry or capsule): Yucca, Dasylirion, Dracaena.

VII. *ASPARAGOIDEAE* (rhizome subterranean, sympodial; berry): Asparagus, Ruscus, Polygonatum, Convallaria, Paris, Trillium.

VIII. *OPHIOPOGONOIDEAE* (short rhizome, sometimes with suckers, with narrow or lanceolate radical leaves; P or (P); anthers introrse or semi-introrse; ovary sup. or $\frac{1}{2}$-inf.; fruit with thin pericarp and 1—3 seeds with fleshy coats): Sansevieria, Ophiopogon.

IX. *ALETROIDEAE* (short rhizome with narrow or lanceolate radical leaves; (P); anthers semi-introrse; capsule loculicidal; seeds ∞, with thin testa): Aletris (only genus).

X. *LUZURIAGOIDEAE* (shrubs or undershrubs with erect or climbing twigs; infl.-twigs usually many-flowered, cymose, rarely 1-flowered, with scaly bract at base; both whorls of P. alike or not; berry with spherical seeds): Luzuriaga, Lapageria.

XI. *SMILACOIDEAE* (climbing shrubs with net-veined leaves; flrs. small in axillary umbels or racemes or terminal panicles; loc. with 1 or 2 orthotropous or semi-anatropous ovules): Smilax.

[Placed in Coronarieae by Benth.-Hooker, in Liliiflorae by Warming.]

Liliiflorae. The 8th cohort (Engler) of Monocotyledons (p. 126). The 5th cohort (Warming) of Monocotyledons (p. 137).

Lilium Tourn. ex Linn. Liliaceae (v). 45 sp. N. temp. Herbs with scaly bulbs (p. 152), leafy stems and flrs. in racemes. The honey is secreted in long grooves at the bases of the perianth-leaves. The flrs. of many sp. are adapted to Lepidoptera. *L. Martagon* L. gives off its scent at night (cf. Oenothera). *L. bulbiferum* L. is reproduced vegetatively by bulbils in the leaf-axils. In most sp. with hanging flrs. the capsule when ripe stands vertically upwards, so that the seeds can only escape when it is shaken. Many sp. of lily are garden favourites.

Limnanthaceae. Dicotyledons (Archichl. Sapindales). A very small order (2 gen. with 5 sp. N. Am.) sometimes united to Geraniaceae, but with the ovules as in coh. Sapindales. Herbs with exstip. alt. leaves and regular ☿ flrs., 3—5-merous, with two whorls of sta. Ovary 3—5-loc., ovules 1 in each loc., ascending, the micropyle facing outwards and downwards. Fruit a schizocarp. Seeds exalbuminous. *Genera:* Limnanthes, Floerkea. Placed in Geraniaceae by Benth.-Hooker, in Gruinales by Warming.

Limnanthemum S. P. Gmel. Gentianaceae (II). 20 sp. trop. and temp. *L.* (*Villarsia*) *nymphaeoides* Hoffmgg. et Link, S. England, is a water-plant with habit of Nymphaea, and so are several others. The infl. appears to spring from the top of the leaf-stalk, but really the floating leaf springs from the infl. axis. As Goebel points out, this is an advance upon the Nymphaea construction, as the materials going from leaf to seeds have not to travel to the bottom of the pond and up again.

Limnanthes R. Br. Limnanthaceae. 4 sp. Pacific N. Am.

Limnobium Rich. (*Hydromystria* G. F. W. Mey., *Trianea* Karst.). Hydrocharitaceae. 3 sp. Am. *L.* (*H.*) *stoloniferum* Griseb. (*T. bogotensis* Karst.) is a small floating plant often cultivated. It reproduces vegetatively by 'runners' (cf. Hydrocharis). Its root-hairs are used to show circulation of protoplasm. Only the ♀ plant is known in Eur.

Limnocharis Humb. et Bonpl. Butomaceae. 1 sp. trop. Am. [*L. Humboldtii* Rich. = *Hydrocleys Commersonii* Rich.]

Limodorum (Tourn.) Linn. Orchidaceae (4). 1 sp. S. Eur. A leafless saprophyte with no chlorophyll (cf. Epipogum). The 4 lateral sta. are sometimes fertile.

Limonia Linn. Rutaceae (x). 6 sp. trop. Afr. and As. Some sp. in the leaf-axils have thorns (leaves of branch, as in Cactaceae). The fruit of *L. acidissima* L. is used in Japan as a substitute for soap.

Limoniastrum Moench. Plumbaginaceae. 3 sp. Medit.

Limosella Linn. Scrophulariaceae (II. 8). 7 sp. cosmop. *L. aquatica* L., mud-wort, in Brit. (rare), a small plant growing on the banks of ponds. It multiplies by runners.

Linaceae. Dicotyledons (Archichl. Geraniales). 9 gen. with 120 sp., cosmop. Most are herbs and shrubs with alt. entire often stip. leaves. Infl. cymose, a dichasium or cincinnus, the latter usually straightening out very much and looking like a raceme (p. 65). Flr. ☿, regular, usually 5-merous. K 5, quincuncial; C 5, imbricate or convolute; A 5, 10 or more, often with staminodes, united at base into a ring; $\underline{G}$ (2—3—5), multi-loc., often with extra partitions projecting from the midribs of the cpls., but not united to the axile placentae; ovules 1 or 2 per loc., pendulous, anatropous, with the micropyle facing outwards and upwards. Septicidal capsule, or drupe. Embryo usually straight, in fleshy endosperm. Linum (flax, linseed) is economically important. *Chief genera:* Radiola, Linum, Hugonia. [Placed in Geraniales by Benth.-Hooker (who unite Erythroxylaceae to L.), in Gruinales by Warming.]

Linaria Tourn. ex Mill. (incl. *Cymbalaria* Medic., *Elatine* Rupp., *Elatinoides* Wettst.). Scrophulariaceae (II. 5). 125 sp. N. Hemisph. and S. Am., chiefly extra-trop. 7 in Brit. (toad-flax): *L. vulgaris* Mill. is the commonest (yellow toad-flax). The plant is a perennial, each year's growth arising from an adventitious bud upon the summit of the root. The flr. is closed at the mouth; honey is secreted by the nectary at the base of the ovary and collects in the spur. The only visitors are the larger bees, which are able to open the flr., and whose tongues are long enough to reach the honey. Peloria of the flr. is frequently observed; a terminal flr. appears upon the raceme and is symmetrical in structure, with 5 spurs upon the corolla and a tubular mouth. Sometimes flrs. of this type occur all down the raceme. Another interesting sp. is *L. Cymbalaria* Mill., the ivy-leaved toad-flax, found on walls in many parts of Brit. Before fertilisation the flrs. are positively heliotropic and stand erect; after it they become negatively heliotropic and bend downwards, seeking out the dark crannies in the substratum, where the seeds ripen.

Lindelofia Lehm. Boraginaceae (IV. 1). 2 sp. Himal.

Lindera Thunb. Lauraceae (II). 60 sp. Japan to Java and N. Am. *L. Benzoin* Meissn. has aromatic bark (antifebrile).

Lindernia All. = Vandellia Linn.

Lindheimera A. Gray et Engelm. Compositae (V). 1 sp. Texas.

Lindsaya Dryand. Polypodiaceae. 50 sp. chiefly trop.

Lineae (Benth.-Hooker) = Linaceae.

Linnaea Gronov. (excl. *Abelia* R. Br.) Caprifoliaceae (III). 1 sp. Eur. N. Am., *L. borealis* L., which occurs in a few localities in Scotland. The ovary is covered with glandular hairs. Sta. 4, didynamous. Two loculi are ∞-ovulate and sterile, the other 1-ovulate and fertile.

Linociera Sw. (*Mayepea* Aubl.). Oleaceae (I. 3). 50 sp. trop.

Linum Tourn. ex Linn. Linaceae. 90 sp. temp. and sub-trop., esp. Medit. 4 in Brit., of which *L. catharticum* L. (purging flax) is common, while *L. usitatissimum* L. (common flax or linseed) is an introduction, it being very largely cultivated in Ireland and elsewhere. The flrs. are in sympodial cincinni. Several sp. are heterostyled (dimorphic), *e.g.* the common red one of gardens, *L. grandiflorum* Desf. Illegitimate pollination in this species produces absolutely no seed at all (p. 95). The seed has a mucilaginous testa which swells on wetting (p. 105).

Flax is the fibre of *Linum usitatissimum* L., obtained by rotting off the softer tissues in water. The seeds (linseed) yield an oil by pressure, and the remaining 'cake' (cf. Gossypium) is used for cattle-feeding, &c.

Liparis Rich. (incl. *Cestichis* Thou.). Orchidaceae (8). 100 sp. trop. and temp. (1 in Brit., rare).

Lippia Houst. ex Linn. Verbenaceae (II). 100 sp. trop. Am., Afr. The leaves of *L. citriodora* H. B. et K. yield an aromatic oil used in perfumery under the name Verbena-oil. Some sp. have axillary thorns.

Liquidambar Linn. Hamamelidaceae. 4 sp. As., N. Am. Flrs. monœcious, apetalous, the male in upright spikes, the female in heads on pendulous stalks. The seeds are easily shaken out in strong winds. Storax (a fragrant balsam) is obtained from all the sp., but chiefly from *L. orientalis* Mill. (As. min.). *L. styraciflua* L. is the Sweet Gum of N. Am. Its wood is useful.

Liriodendron Linn. Magnoliaceae (1). 1 sp. N. Am., *L. tulipifera* L., the tulip-tree, often cultivated in parks for its handsome flrs. The leaf is polymorphic (*Bot. Jahresb.* 1890, p. 414). The fruit is a samara; the aggregate of samaras upon the receptacle looks much like a pine-cone. The wood is very useful.

Lisianthus Linn. Gentianaceae (I. 2). 10 sp. W. Ind., Cent. Am.

Lissochilus R. Br. Orchidaceae (16). 30 sp. trop. Afr.

Listera R. Br. Orchidaceae (4). 10 sp. N. temp. *L. ovata* R. Br. (tway-blade) and *L. cordata* R. Br. in Brit. The labellum is bent downwards and forked into two. The rostellum on being touched ruptures violently and ejects a viscid fluid which cements the pollinia to the insect as in Epipactis (see Darwin, *Orchids* p. 115).

Litchi Sonner. Sapindaceae (1). 1 sp. China, *L. chinensis* Sonner., the Litchi or Leechee, largely cultivated for its edible fruit, a nut containing one seed surrounded by a fleshy aril. [Included in Nephelium (q.v.) by Benth.-Hooker.]

Lithophragma Torr. et Gray = Tellima R. Br.

Lithospermum (Tourn.) Linn. Boraginaceae (IV. 4). 40 sp. temp.; 3 in Brit. (gromwell.).

Litsea Lam. Lauraceae (II). 100 sp. trop. As. Austr.

Littonia Hook. Liliaceae (1). 2 sp. S. Afr. Like Gloriosa.

Littorella Berg. Plantaginaceae. 2 sp., 1 in S. Am., and *L. lacustris* L. (shore-weed) in Eur. (incl. Brit.). This plant exhibits two forms, one in water, another on land (p. 162). The land form has a rosette of narrow leaves about 3 cm. long, which spread out upon the ground and show distinct dorsiventral structure. The flrs. are borne in groups of 3, one ♂ on a long stalk between two sessile ♀ flrs. The stigmas of the latter are ripe before the sta. emerge from the former. Both sta. and style are very long and the flrs. are wind-pollinated. Fruit a nut. The water form has much larger leaves which grow erect and are cylindrical (centric) in form and internal structure; no flrs. are produced, but the plant multiplies largely by the formation of runners. It is common on the shores of lakes in Brit. and is often mistaken for Isoetes.

Livistona R. Br. Palmae (I. 2). 12 sp. Indo-mal., Austr. Tall trees with fan leaves and panicles of ☿ flrs. Fruit a berry.

Lloydia Salisb. Liliaceae (V). 5 sp. N. temp. *L. serotina* Sweet (*L. alpina* Salisb.) on Snowdon. See Müller's *Alpenblumen*.

Loasa Adans. Loasaceae. 81 sp. Mexico and S. Am., chiefly Mts. of Chili and Peru. Several sp. are cultivated for their handsome flrs.; they possess, however, stinging hairs. The flrs. are generally yellow and face downwards. The nectaries, formed of combined staminodes (see order), are large and conspicuous. The petals are boat-shaped and conceal the groups of sta. The flrs. are visited by many insects. *L. triloba* Juss. has, according to Gilg, cleistogamic flrs. on the lower branches.

Loasaceae. Dicotyledons (Archichl. Parietales). 13 gen. with 120 sp. Andine plants, many of which are favourites in gardens. They are mostly herbs, frequently twining, with opp. or alt., rarely stip., leaves. The epidermis bears hairs of various kinds; especially common are grapple-hairs and stinging-hairs, the latter frequently rather formidable. The flrs. are usually in cymes, often sympodial, yellow (rarely white or red), ☿, usually 5-merous. The receptacle is deeply hollowed out, so that the flr. is epigynous. K 5, imbricate; C 5, free or united; A 5—∞. In the genera with ∞ sta. there is much difference as to the arrangement. In Mentzelia they are evenly distributed round the style, the outermost in some sp. being sterile. In other genera it is the ante-sepalous sta. that are sterile, and in some, *e.g.* Loasa, Blumenbachia, 3 or more of the staminodes are united to form a large coloured nectary, whose mouth is towards the centre of the flr. and partly obstructed by the other staminodes. Ovary inferior, of 1 or more commonly 3—5 cpls., with parietal placentation; ovules 1, several, or ∞, anatropous, with one integument; style simple. Fruit various, often a capsule, sometimes spirally twisted. Endosperm or not.

Classification and chief genera (after Gilg):

I. *GRONOVIOIDEAE* (ovary of 1 cpl.): Gronovia.

II. *MENTZELIOIDEAE* (> 1 cpl.; no staminodes, or at least not nectariferous scales): Mentzelia.

III. *LOASOIDEAE* (> 1 cpl.; staminodes present, often united to form nectariferous scales): Loasa, Blumenbachia.

[Placed in Passiflorales by Benth.-Hooker, in Passiflorinae by Warming.]

Loaseae (Benth.-Hooker) = Loasaceae.

Lobelia Plum. ex Linn. Campanulaceae (III). 200 sp. trop. and temp.; 2 in Brit., one in lakes (*L. Dortmanna* L.). Several are commonly grown in gardens. The flr. (see order) is twisted upon its axis through 180°, and is zygomorphic. The anthers are syngenesious as in Compositae and the style pushes through the tube thus formed, driving the pollen out at the top. Finally the style emerges, the stigmas separate, and the female stage begins. Not uncommonly the style is unable to push through the tube, or at least does not do so, and self-fertilisation occurs when the stigmas open. [See order, and compare Campanula, Phyteuma, Jasione and Compositae.]

Lockhartia Hook. Orchidaceae (28). 20 sp. trop. Am. No tubers; leaves crowded together.

Lodoicea Comm. Palmae (II. 3). 1 sp. *L. Sechellarum* Labill., Seychelles (p. 148), the double coco-nut or Coco de mer. Diœcious, with enormous spadices. The fruit is the largest known and takes 10 years to ripen. The nut is bilobed. The fruits used to be found floating in the Indian Ocean long before the tree was discovered (see *Treas. of Bot.*).

Lœflingia Linn. Caryophyllaceae (II. 3). 5 sp. Medit., Cent. As., N. Am.

Logania R. Br. Loganiaceae. 21 sp. Austr., N. Z.

Loganiaceae. Dicotyledons (Sympet. Contortae). 32 gen. with about 350 sp. of trop. plants. A few occur in warm temp. regions (Am., As., N. Z., but none in Eur.). They include trees, shrubs, and herbs with opp. stip. leaves; the stipules are often very much reduced. Many are climbing plants, of which Strychnos is especially interesting. The infl. is as a rule cymose, of very various types; the flrs. with bracts and bracteoles, usually regular, ☿, and 4—5-merous, with occasional increase in number in corolla and andrœceum. Disc small or absent. K (4—5), imbricate; C (4—5), valvate, imbricate, or convolute; A 4—5, rarely 1, epipetalous; $\underline{G}$ (2), anteroposterior, 2-loc., or rarely imperfectly so, or 1- or more-loc.; style simple; ovules usually ∞, amphi- or ana-tropous. Capsule, berry, or drupe. Endosperm. The L. are nearly allied to Apocynaceae, Gentianaceae, Solanaceae, Scrophulariaceae and Rubiaceae. See full discussion by Solereder in *Nat. Pfl.* *Chief genera:* Logania, Spigelia, Strychnos, Fagraea, Buddleia, Desfontainea. [Placed in Gentianales by Benth.-Hooker, in Contortae by Warming.]

Loiseleuria Desv. Ericaceae (I. 3). 1 sp. *L. procumbens* Desv. (*Azalea procumbens* L.), the trailing Azalea, north circumpolar. It is found in the Highlands of Scotland, where in parts the flat hill tops are carpeted with it (p. 182). The leaves are very wiry, and rolled back at the margins, thus protecting the stomata from too free transpiration. The petioles of the topmost pair of open leaves are grooved and closely appressed to one another, thus protecting the bud. In its native habitat the plant lies close on the ground, but in gardens becomes erect in habit. The flrs. are regular (this distinguishes L. from the true Azalea; see A. and classification of order); they are protogynous and come out very shortly after the melting of the snow. In Scotland they are self-pollinated, the sta. bending inwards to touch the stigma; this is not the case in the Alps.

Lolium Linn. Gramineae (XII). 6 sp. Eur., N. Afr., temp. As. *L. perenne* L. in Brit. (rye-grass). The spikelets are arranged in a 2-ranked spike, and placed edgewise (this distinguishes the sub-tribe *Lolieae* from the *Leptureae*, to which Triticum and Hordeum belong). The rye-grasses are valuable pasture and fodder grasses.

Lomandra Labill. (*Xerotes* R. Br.) Liliaceae (III). 30 sp. Austr. Diœcious. Placed in Juncaceae by Benth.-Hooker.

Lomaria Willd. Polypodiaceae. 40 sp. cosmop., chiefly S. temp. *L. Spicant* Desv. (*Blechnum boreale* Sw.) is the hard-fern or northern fern, common on hills in Brit. There are fertile and barren leaves, the latter larger.

Lomatia R. Br. Proteaceae (II). 9 sp. E. Austr., Tasm., Chili.

Lomatophyllum Willd. Liliaceae (III). 3 sp. Mauritius, Bourbon (p. 148).

Lonas Adans. Compositae (VII). 1 sp. South-west Medit.

Lonchitis Linn. Polypodiaceae. 2 sp. S. Hemisph.

Lonchocarpus H. B. et K. Leguminosae (III. 8). 60 sp. trop. Am. Afr. Austr.

Lonicera Linn. Caprifoliaceae (IV). 100 sp. N. Hemisph. *L. Periclymenum* L. (honeysuckle or woodbine), and others, in Brit. They are mostly erect shrubs, a few twining, with opp. frequently connate leaves. In the axils of the leaves are found in many sp. (*e.g. L. tatarica* L.) serial buds, of which the lowest gives rise to the flrs. These are usually in pairs, the central flr. of the small dichasium not being developed. The flr. is frequently zygomorphic, and gives rise to a berry. In some sp. the pair of flrs. produces two independent berries, in others the berries fuse into one as they form. Some sp. exhibit the 'fusion' even earlier; and one finds two corollas seated upon what at first glance appears a single inferior ovary. Dissection of this shows, however, that in most cases the two ovaries are side by side, free from one another, in a common hollow axis; in a few cases, however, the union is more complete. The flr. of the honeysuckle is visited chiefly by hawk-moths (at night). The flr. opens in the evening, the anthers having dehisced shortly before this. The style projects beyond the anthers. The flr. moves into a horizontal position at the same time. At first the style is bent downwards and the sta. form the alighting place for insects. Later on the style moves up to a horizontal position, the sta. shrivel and bend down, and this is complete by the second evening when the next crop of buds is opening. At the same time the flr. has changed from white to yellow in colour. The length of the tube prevents any but very long-tongued insects from obtaining honey.

Lopezia Cav. Onagraceae (VII). 12 sp. Cent. Am. The flr. is zygomorphic. The two upper petals are bent upwards a little way from their base, and at the bend there seems to be a drop of honey. In reality this is a dry glossy piece of hard tissue; like the similar bodies in Parnassia it deceives flies. There are real nectaries however at the base of the flr. There are two sta., of which the posterior only is fertile; it is enclosed at first in the anterior one, which is a spoon-shaped petaloid staminode. In the early stage of the flr., while the style is still quite short and undeveloped, insects alight on the sta., later the style grows out into the place at first occupied by the sta., which now bends upwards out of the way. Self-fertilisation seems almost impossible. In *L. coronata* Andr. and other sp. there is an upward tension in the sta., a downward in the staminode, and an explosion occurs when an insect alights.

Lophophytum Schott et Endl. Balanophoraceae. 4 sp. trop. S. Am.

Loranthaceae. Dicotyledons (Archichl. Santalales). 21 gen., 520 sp. An extremely interesting order of parasitic plants, possessing green leaves (p. 176). The only genus in Brit. is Viscum, the mistletoe, but many others are found in the Tropics.

They are mostly semi-parasitic shrubs, attached to their host-plants by means of suckers or haustoria—usually regarded as modified adventitious roots. The stem is sympodial, often dichasial (*e.g.* Viscum), the leaves usually evergreen and of leathery texture. The infl. is cymose, the flrs. usually occurring in little groups of 3 (or 2, by abortion of the central flr.). In cases where the flrs. possess a stalk, the bract is united to this as far as the origin of the next branch (for details see Viscum and Loranthus). The receptacle is hollowed out, and the perianth springs from its margin. In the *Loranthoideae* there is below the perianth an outgrowth of the axis in the form of a small fringe—the *calyculus*—about whose morphology there has been some discussion. The perianth may be either sepaloid or petaloid. Flrs. ☿ or unisexual. Sta. as many as, and (as in Proteaceae) united with, the perianth-leaves. The pollen is often developed in a great number of loculi, separate from one another, though often becoming continuous when mature. Ovary 1-loc., sunk in, and united with, the receptacle, the ovules not differentiated from the placenta. Embryo-sacs more than one, curiously lengthened (cf. Casuarina). The fruit is a pseudo-berry or -drupe, the fleshy part being really the receptacle. Round the seed is a layer of viscin, a very sticky substance. [For full details of the many interesting features of this order, the infl., flr., pollen, development and structure of ovule and embryo-sac, fruit, seed, germination, haustoria, &c., see Engler in *Nat. Pfl.* and papers by Wiesner in *Sitz. k. Akad.* Wien, CIII. 1894, and Keeble in *Trans. Linn. Soc.* v. 1896.]

Classification and chief genera (after Engler):

I. *LORANTHOIDEAE* (with calyculus): Struthanthus, Loranthus, Psittacanthus.

II. *VISCOIDEAE* (without calyc.): Arceuthobium, Viscum.

Loranthus Linn. Loranthaceae (I). 200 sp. trop. Semi-parasites. The ☿ or unisexual flrs. are in small cymes, the bracts adnate to the peduncles. Fruit like that of Viscum. See *Nat. Pfl.*, Eichler's *Blüthendiag.* and papers by Wiesner and Keeble (see order).

Lotononis Eckl. et Zeyh. Leguminosae (III. 3). 60 sp. Afr., Medit.

Lotus (Tourn.) Linn. Leguminosae (III. 5). 80 sp. temp. Eur., As., S. Afr., Austr. *L. corniculatus* L., bird's foot trefoil, and others, in Brit. The floral mechanism is of interest, being typical of many of the order (q.v.). The keel is united above and below, leaving only a small opening at the apex. The pollen is shed in the bud into the tip of the keel, and the filaments of five of the sta. thicken out below the anthers, forming together a piston, which, when the keel is depressed, forces the pollen out in a little stream at the apex. The style is immersed in the pollen, but only becomes receptive on being rubbed, so that the flower has a good chance of cross-fertilisation. The plant is useful for pasturage.

Lucuma Molina (excl. *Vitellaria* Gaertn. f.). Sapotaceae (I). 4 sp. S. Am., Austr., New Caled. The fruit of *L. bifera* Molina is edible.

Ludwigia Linn. Onagraceae (I). 20 sp. N. Am. and trop.; also one (*L. palustris* Ell.) in Eur. (incl. Brit.).

Luffa (Tourn.) Linn. Cucurbitaceae (III). 7 sp. trop., all but one in Old World. *L. cylindrica* M. Roem. (*L. aegyptiaca* Mill.) furnishes the well-known loofah or bath sponge, which consists of the vascular bundle net of the pericarp. The fruit of most sp. is edible.

Lunaria Tourn. ex Linn. Cruciferae (II. 11). 2 sp. Eur., *L. rediviva* L. and *L. biennis* Moench (*L. annua* L.); the latter is the honesty of gardens.

Lupinus (Tourn.) Linn. Leguminosae (III. 3). 100 sp. Am., Medit. Floral mechanism like that of Lotus. The fruit explodes, its valves twisting spirally. Several sp. of lupin are cultivated for their flrs., or used as fodder plants.

Luzula DC. Juncaceae. 40 sp. temp., chiefly Old World; 6 in Brit. (wood-rush). Rhizome as in Juncus; leaves usually flat.

Luzuriaga Ruiz et Pav. (*Enargea* Banks). Liliaceae (X). 3 sp. S. Am., N.Z., &c.

Lycaste Lindl. Orchidaceae (18). 30 sp. trop. Am. Epiphytes. A chin is formed by an axial outgrowth from the base of the column.

Lychnis (Tourn.) Linn. (incl. *Agrostemma* Linn., *Githago* Adans., *Melandrium* Roehl., *Viscaria* Riv.). Caryophyllaceae (I. 1). A genus of ill-defined limits, divided in *Nat. Pfl.* under several of the genera named. 40 sp. N. temp.; 6 in Brit., including *L. Flos-cuculi* L. (ragged robin), *L. dioica* L. (red campion), *L. Viscaria* L. (catch-fly) and *L. Githago* Scop. (corn-cockle). The flrs. are protandrous, and adapted to bees and Lepidoptera. The catch-fly gets its name from the glandular hairs upon the stalks. *L. dioica* is diœcious, and the female plant is much stouter and of coarser growth than the male (a parallel, but not a homologue, of the usual state of things in animals). The flrs. often show the sta. filled with a black or brown powder, instead of pollen; this consists of the spores of the fungus *Ustilago antherarum*, which are thus distributed from plant to plant, like pollen, by the visiting insects.

Lycium Linn. Solanaceae (II). 70 sp. temp. Many have thorny twigs; *L. afrum* L. (Kaffir thorn) is used for hedges in S. Afr. *L. barbarum* L. is often cultivated under the name tea-plant.

Lycopersicum Hill. Solanaceae (II). 10 sp. S. Am. *L. esculentum* Mill. (*Solanum Lycopersicum* L.) is the tomato or love-apple, cultivated for its fruit. Included in Solanum in *Nat. Pfl.*

Lycopodiaceae. Lycopodinae (Homosporous). 2 genera (Lycopodium, Phylloglossum) with 95 sp., trop. and temp. Of these all but one belong to Lycopodium itself. The fertilised ovum gives rise directly to the leafy plant; the embryo has a suspensor and a foot; and its upper part at first forms a tuber-like organ, the *protocorm*, from which the leaves and stem develope. In P. the stem is short and unbranched, in L. long and much branched, bearing small simple leaves, and roots developed in acropetal succession. The sporangia are axillary, and form as a rule a dense terminal cone or strobilus. The spores are all of one kind and give rise on germination to fairly large monœcious prothalli.

Lycopodineae. One of the main divisions of Pteridophyta. They are mostly leafy plants, with well developed stems and small unbranched leaves. The sporophylls are usually massed together into cones, recalling to mind those of the Gymnosperms. They are classified as follows.

A. Homosporous.

1. *Lycopodiaceae:* Roots present; sporangia simple, in axils of leaves which are more or less modified.
2. *Psilotaceae:* No roots; sporangia plurilocular, sunk in tissue of bilobed sporophylls.

B. Heterosporous.

3. *Selaginellaceae:* Stem long, leaves small; sporangia in leaf axils.
4. *Isoetaceae:* Stem tuberous, leaves awl-shaped, with sporangia sunk in their bases.

The position of order 4 is very doubtful, and it is often placed in Filicineae Eusporangiatae.

Lycopodium Linn. Lycopodiaceae. 94 sp. trop. and temp. 5 occur in Brit., chiefly in mountain districts, where they are known as club-mosses. The commonest is *L. clavatum* L. (often called stag-horn moss); the others are *L. Selago* L., *L. alpinum* L., *L. annotinum* L., and *L. inundatum* L. All but the last are xerophytic evergreen plants with hard wiry leaves. The stem branches frequently, apparently dichotomously, but in reality usually in a monopodial manner. Upon it are borne the roots, which branch dichotomously, and are developed in acropetal succession. The leaves, narrow and unbranched, are usually placed spirally upon the stem, but in some sp. form four ranks, as in most Selaginellas. Many sp. have vegetative reproduction by aid of small bulbils developed in the leaf axils.

The sporangia are all alike in structure, containing spores of one kind only. They are placed upon the bases of leaves which are usually crowded together to form a terminal spike or strobilus. In *L. Selago* some or all of the sporangia are often replaced by small bulbils (cf. Polygonum viviparum, Allium sp., Globba, &c.).

Lycopsis Linn. Boraginaceae (IV. 3). 3 sp. Eur., As. *L. arvensis* L., small bugloss, in Brit.

Lycopus Tourn. ex Linn. Labiatae (VI. 11). 10 sp. N. temp. *L. europaeus* L., gipsywort, in Brit.

Lygeum Linn. Gramineae (VI). 1 sp. Medit. *L. Spartum* Loefl., one of the esparto-furnishing grasses (see Stipa and Ampelodesma).

Lygodium Sw. Schizaeaceae. 20 sp. trop. and temp. They are of interest as twining ferns. The stem remains comparatively undeveloped, but the leaf has unlimited apical growth, and the long midrib twines around supports like the stem of the hop, bearing pinnae at intervals. The leaves are borne on the stem in one dorsal row. The sporangia are in a double row on the back of the fertile pinnae, and each is surrounded by a cup-like indusium.

Lyonia Nutt. Ericaceae (II. 4). 16 sp. E. As., N. Am., 1 circumpolar. Like Andromeda, into which some sp. are sometimes placed.

Lyperia Benth. Scrophulariaceae (II. 7). 33 sp. S. Afr. United to Chaenostoma in *Nat. Pfl.*

Lysimachia (Tourn.) Linn. Primulaceae (III). 60 sp. temp. and sub-trop., esp. N. Hemisph.; 4 sp. in Brit. *L. vulgaris* L., yellow loosestrife, is said by Müller (*Fert. of Flrs.*) to occur in two forms, one in sunny places with large flrs. suited to crossing, and one in shady spots with small self-fertilised flrs. *L. nemorum* L., yellow pimpernel is common, and *L. Nummularia* L., moneywort, is frequent, though it is said never to set seed in Brit.

Lysipomia H. B. et K. Campanulaceae (III). 7 sp. Andes.

Lythraceae. Dicotyledons (Archichl. Myrtiflorae). 21 gen. with 360 sp., in all zones but the frigid. Herbs, shrubs, or trees; leaves usually opp., entire, simple, with very small stipules. Flrs. in racemes, panicles, or dichasial cymes, ☿, regular or zygomorphic, usually 4- or

6-merous. The axis ('calyx-tube') is hollow, generally tubular. The sepals are valvate, and frequently possess an epicalyx, formed, as in Potentilla, of combined stipules. Petals crumpled in bud, sometimes absent. Sta. inserted (often very low down) on calyx-tube, typically twice as many as sepals, but sometimes fewer or ∞. Ovary superior, with simple style and usually capitate stigma; it is 2—6-loc., at the base at least, rarely 1-loc. with parietal placenta. Ovules usually ∞, anatropous, ascending. The flrs. of Lythrum (q.v.) and others are heterostyled. Dry fruit, usually capsular. No endosperm. *Chief genera:* Peplis, Lythrum, Cuphea, Lagerstroemia. Benth.-Hooker include Oliniaceae, and place it in Myrtales; by Warming it is placed in Myrtiflorae.

Lythrum Linn. Lythraceae. 23 sp. temp., in damp places; 2 in Brit., *L. Salicaria* L. (purple loosestrife) and another. The 6-merous flrs. are solitary or in small axillary dichasia like those of Labiatae. Each has 12 sta. in two whorls of different length, and the style again is of different length to any of the sta. Three forms of flr. occur, each on a separate plant; they are distinguished as long- mid- and short-styled flrs., according to the length of the styles. The diagram illustrates the arrangement of parts (S = stigma, A = anthers, B = base of flr.), as seen in side view of the flr. Darwin (*Forms of Flrs.*) was the first to show the meaning of this trimorphism. It is evident that an insect visiting the flrs. will tend on the whole to transfer pollen from A_3 to S_3, A_2 to S_2, A_1 to S_1, rather than from sta. of one length to style of another, for the insect will always enter these zygomorphic flrs. in the same way and to the same depth. The sta. and style project so far that an insect can alight directly upon them. Darwin showed by a long series of experiments that the best results are obtained by pollinating S_3 from A_3, or S_1 from A_1, &c., *i.e.* by crossing two plants. The number of seeds thus obtained is much greater and their fertility higher than if S_2 or S_1 be fertilised from A_3, or any other such union be made. Fertilisation of a stigma by sta. of corresponding length Darwin terms *legitimate*, by sta. of a different length *illegitimate* fertilisation. The offspring of illegitimate fertilisation are few in number and have the sterility and other sexual characters of hybrids.

S_3	A_3	A_3
A_2	S_2	A_2
A_1	A_1	S_1
B	B	B
long-styled	mid-styled	short-styled

A curious point, as yet entirely unexplained, is that here, as in nearly all other heterostyled plants, the longer the sta. the larger the pollen grains, and the longer the style the larger are the papillae of the stigma.

The whole subject of heterostylism is still much in the dark. We know nothing beyond the facts, and the cause, even the advantage, of the phenomenon remains obscure. We can only class it as one of the general methods favouring cross-fertilisation. [See Darwin, *loc. cit.*, Loew, *Einführung in die Blütenbiologie*, and p. 95.]

Maba Forst. Ebenaceae. 63 sp. trop. and subtrop. The wood of some sp. is used as a substitute for ebony. Fruit of some sp. edible.

Macadamia F. Muell. Proteaceae (II). 3 sp. Austr. (nut-tree). The seeds are edible, tasting like filberts.

Macaranga Thou. Euphorbiaceae (A. II. 2). 90 sp. Old World trop. *M. caladifolia* Becc. has hollow peduncles inhabited by ants (p. 115).

Macfadyena A. DC. Bignoniaceae (I). 8 sp. S. Am.

Machaerium Pers. Leguminosae (III. 8). 60 sp. trop. Am. Resembles Dalbergia. Many are lianes, climbing by sensitive lateral shoots, and provided with recurved stipular thorns (see p. 172).

Mackaya Harv. = Asystasia Blume.

Macleania Hook. Ericaceae (III. 8). 12 sp. W. trop. Am.

Macleya Rchb. = Bocconia Linn.

Maclura Nutt. Moraceae (I). 1 sp. South-west U.S., *M. aurantiaca* Nutt., the bow-wood or Osage orange. The tree bears thorns (branches). Flrs. diœcious, the ♂ in pseudo-racemes, the ♀ in pseudo-heads. The individual flrs. are like those of Morus. After fertilisation each ♀ flr. produces an achene enclosed in the fleshy perianth, and at the same time the common receptacle swells up into a fleshy mass, so that a large yellow multiple fruit is formed. The wood is used for bows, carriage-poles, &c. The leaves are used for feeding silkworms. [For *M. tinctoria* D. Don, &c., see Chlorophora.]

Macroplectrum Pfitz. = Angraecum Bory.

Macrozamia Miq. Cycadaceae. 14 sp. Austr.

Madia Molina. Compositae (V). 12 sp. W. Am.

Maerua Forsk. Capparidaceae (III). 20 sp. trop. Afr., As. The fruit is a berry, constricted between the seeds like a lomentum.

Maesa Forsk. Myrsinaceae (III). 35 sp. trop., except Am.

Magnolia Linn. Magnoliaceae (I). 21 sp. As., N. Am. (esp. trop.). Trees with sheathing stipules covering the bud, and terminal flrs. The perianth is petaloid, except sometimes the outermost leaves, and is in whorls. The sta. and cpls. are ∞, on a lengthened torus. The flr. is protogynous, and in the sp. usually grown in England is said to act as a 'trap flower' (p. 98). The petals at first, while the stigmas are ripe, stand vertically, leaving only a small opening into the flr. Insects resort to it (? beetles) for honey and shelter, and are unable to escape until the second stage supervenes, when, the anthers having shed their pollen, the flr. opens widely. The fruit is an aggregate of follicles; each dehisces by its *dorsal* suture, and the seed dangles out of it on a long thread formed by the unravelling of the spiral vessels of the funicle. The outer integument of the ovule becomes fleshy as it ripens, and the seeds may thus be distributed by birds. Several sp. are cultivated for their magnificent flrs.

Magnoliaceae. Dicotyledons (Archichl. Ranales). 9 gen. with 70 sp.

of trop. and sub-trop. trees and shrubs (some climbing). They have alt. leaves, which in the *Magnolieae* have big stipules, united to form a thimble-like hood, covering in the bud all the younger leaves. As each leaf expands it throws off the hood of the next older leaf. The flrs. are terminal (in most sp.) or axillary, usually solitary, ☿ or unisexual. In the *Magnolieae* the perianth is cyclic, in the rest of the order it is spiral, as are the sta. and cpls. throughout. The perianth is usually petaloid. Sta. ∞, hypogynous. Cpls. usually ∞, on a long torus. Fruit a follicle, berry, or samara. Seed albuminous, the endosperm not ruminate. The timber of most M. is good. Illicium, &c., furnish economic products. Magnolia and Liriodendron are cultivated for their flrs. &c.

Classification and chief genera (after Prantl).

A. Leaves with stipular hoods:

1. *Magnolieae:* Magnolia, Liriodendron.

B. Leaves without hoods:

2. *Schizandreae* (climbing): Kadsura, Schizandra.
3. *Illicieae* (erect): Illicium, Drimys.

Mahernia Linn. Sterculiaceae. 30 sp. S. Afr. Included in Hermannia in *Nat. Pfl.*

Mahonia Nutt. = Berberis Linn.

Maianthemum Weber. Liliaceae (VII). 1 sp. N. temp. (incl. Brit.), *M. Bifolium* DC. (*M. Convallaria* Weber). Flr. 2-merous, protogynous.

Maieta Aubl. Melastomaceae (I). 8 sp. trop. Am. Some have bladdery outgrowths of the leaves inhabited by ants (cf. Duroia).

Malachium Fries = Stellaria Linn.

Malachra Linn. Malvaceae (III). 5 sp. trop. Am.

Malacocarpus Salm-Dyck = Echinocactus Link et Otto.

Malacothrix DC. Compositae (XIII). 15 sp. Calif.

Malaxis Soland. ex Sw. Orchidaceae (8). 1 sp. N. temp. (incl. Brit.), *M. paludosa* Sw. The flr. is twisted through 360°, so that the labellum is again uppermost. Perhaps some ancestral form exhibited the usual orchid pattern. See Darwin's *Orchids*, p. 130.

Malcomia R. Br. (*Malcolmia* Spreng). Cruciferae (IV. 18). 30 sp. Medit.

Malesherbia Ruiz et Pav. Malesherbiaceae. 18 sp. west S. Am.

Malesherbiaceae. Dicotyledons (Archichl. Parietales). 1 gen., Malesherbia. United to Passifloraceae by Benth.-Hooker; it differs from P. in having no aril and in having the styles more deeply inserted and widely separated. It differs from Turneraceae in having no aril, in the aestivation of the corolla, and in the persistent receptacle.

Mallotus Lour. Euphorbiaceae (A. II. 2). 80 sp. Old World trop.

Malope Linn. Malvaceae (I). 3 sp. Medit. The 3 leaves of the epicalyx are very large. Cpls. ∞, in vertical rows (see order).

Malpighia Plum. ex Linn. Malpighiaceae (II). 20 sp. trop. Am. Not climbers. Some sp. have stinging hairs; some have cleistogamic flrs.

Malpighiaceae. Dicotyledons (Archichl. Geraniales). 55 gen. with 650 sp., trop., esp. S. Am. Shrubs or small trees, usually climbing, forming a marked feature among the trop. lianes. The stem-anatomy is peculiar (p. 173). Leaves usually opp., entire, stip., frequently gland-dotted. The plants are usually covered with peculiar branched unicellular hairs. Infl. racemose. Flr. ☿, obliquely zygomorphic. K (5), imbricate, often with large glands at the base of (outside) the sepals; C 5, petals usually clawed, imbricate; A 5+5, obdiplostemonous, often fewer, joined in a ring at the base; anthers opening introrsely by longitudinal splits; G̲ (3), obliquely placed in the flr., 3-loc. with axile placentae. One ovule in each loc., pendulous, semi-anatropous, with ventral raphe. Fruit typically a schizocarp breaking into 3 mericarps, but frequently one or more of the loc. abort. The mericarps are often winged, in some cases, *e.g.* Banisteria, like those of Acer. Seed exalbuminous.

Classification and chief genera (after Niedenzu):

I. *Pyramidotorae* (torus pyramidal; mericarps usually winged): Tetrapteris, Banisteria, Acridocarpus.

II. *Planitorae* (torus flat or concave; mericarps not winged): Malpighia, Bunchosia, Byrsonima.

[Placed in Geraniales by Benth.-Hooker, in Aesculinae by Warming.]

Malus Tourn. ex Linn. = Pyrus Tourn.

Malva (Tourn.) Linn. (excl. *Callirhoe* Nutt.). Malvaceae (II). 25 sp. N. temp.; 3 in Brit. Flr. of the ordinary type of the order, with ∞ cpls. Two Brit. sp. *M. sylvestris* L. and *M. rotundifolia* L. (large and small mallow) afford an interesting contrast in floral mechanism, &c. Honey is secreted in little pockets in the receptacle, covered with hairs which exclude rain and very short-tongued insects. The large mallow is very protandrous; the sta. stand up at first in the middle of the flr., and afterwards bend outwards and downwards whilst the styles lengthen and occupy the original positions of the sta. The small mallow has much smaller flrs. which are much less visited by insects (see lists of visitors in Müller's *Fert. of Flrs.*); they go through stages similar to those described above, but at the end of the female stage the styles bend downwards, twist in among the anthers and pollinate themselves (see p. 58).

The leaves in autumn may usually be seen covered with brown spots caused by the fungus *Puccinia malvacearum* (cf. Berberis).

Malvaceae. Dicotyledons (Archichl. Malvales). About 35 gen. with 700 sp. trop. and temp. Herbs, shrubs, or trees, with stip. leaves. Flrs. solitary or in compound cymose infls. made up of cincinni, ☿, regular, usually 5-merous. Very often an epicalyx is present; it is probably an aggregation of bracteoles, but has been regarded as stipular like that of some Rosaceae (q.v.). K 5 or (5), valvate; C 5, convolute, the petals usually asymmetrical; A usually ∞, owing to branching of the inner whorl of sta. (the outer is usually absent), all united below into a tube which is joined to the petals and at first sight makes the corolla appear gamopetalous; the anthers are monothecous (*i.e.* each = half an anther), the pollen grains spiny. $\underline{G}$ (1—∞) frequently (5), multi-loc., with axile placentae. In sub-order I a division of the cpls. by horizontal transverse walls occurs, producing vertical rows of one-ovuled portions. Ovules 1—∞ in each cpl., anatropous, usually ascending, sometimes pendulous. Malvaviscus has a berry, the rest of the order dry fruits, either capsules or schizocarps. Embryo usually curved, surrounded by endosperm. The flrs. are generally protandrous (see Malva and Goethea). Gossypium (cotton), Hibiscus, and others are of economic value. Many are garden favourites.

Classification and chief genera (after Schumann): Bentham and Hooker unite Bombacaceae to Malvaceae and place them in cohort Malvales. Warming places M. in Columniferae.

A. Cpls. in vertical rows.
 I. *Malopeae:* Malope, Kitaibelia.
B. Cpls. in one plane.
 II. *Malveae* (schizocarp; styles as many as cpls.): Abutilon, Lavatera, Althaea, Malva, Anoda.
 III. *Ureneae* (schizocarp; styles twice as many as cpls.): Urena, Goethea, Pavonia.
 IV. *Hibisceae* (capsule): Hibiscus, Gossypium.

Malvales. The 18th cohort (Engler) of Archichlamydeae (p. 129). The 6th cohort (Benth.-Hooker) of Polypetalae (p. 133).

Malvastrum A. Gray. Malvaceae (II). 70 sp. Am. and S. Afr.

Malvaviscus Dill. ex Adans. Malvaceae (III). 10 sp. trop. Am.

Mammea Linn. Guttiferae (IV). 1 sp. W. Ind., *M. americana* L., largely cultivated for its edible fruit, the Mammee or St. Domingo apricot. The flrs. are used in preparing a liqueur (eau de Créole).

Mammillaria Haw. (incl. *Anhalonium* Lem.). Cactaceae (I. 2). 360 sp. trop. Am. Mostly small plants of very condensed form, often almost spherical in outline, with well-marked mammillae (see order). There is a division of the growing point into two in the course of formation of the mammilla, and the part at the base of the mammilla (*i.e.* in the axil) gives rise to the flr. The gynœceum elongates after fertilisation so that the tip of the long red berry is raised clear of the thorns. In some sp. vegetative reproduction and dispersal occurs by the mammillae breaking off and blowing about or adhering to animals. The fruit is edible.

Mandevilla Lindl. Apocynaceae (II. 4). 30 sp. trop. and sub-trop. Am.

Mandragora (Tourn.) Linn. Solanaceae (II). 3 sp. Medit., Himal. (mandrake). For the superstitions connected with this plant, see *Treas. of Bot.*

Manettia Mutis. Rubiaceae (I. 4). 24 sp. trop. Am.

Mangifera Linn. Anacardiaceae (I). 27 sp. Indo-mal. *M. indica* L.

is the mango, everywhere cultivated in the tropics for its fruit, which is a large drupe derived from the 1 cpl. of the flr.

Manihot Tourn. ex Adans. Euphorbiaceae (A II. 4). 80 sp. S. Am. Shrubs and herbs with monœcious flrs. *M. Glaziovii* Müll.-Arg. and other sp. show bud-protection well. The petiole of the young leaf curves upwards and inwards, so that the leaf is brought above the bud, thus protecting it from radiation &c. *M. utilissima* Pohl is the bitter, *M. Aipi* Pohl (*M. palmata* Müll.-Arg.) the sweet cassava or mandioc; both are extensively cultivated in the tropics for their large tuberous roots, which contain much starch, &c., and form a valuable food-stuff. The bitter cassava is the one usually cultivated: its poisonous juice is squeezed out, and finally dissipated in the drying. The ground roots form mandioc or cassava meal, sometimes called Brazilian arrowroot. By a special mode of preparation, tapioca is prepared from the root. The poisonous juice, evaporated to a syrup and thus rendered harmless, forms an antiseptic, known as cassareep, used in preserving meat &c. *M. Glaziovii* is the Ceara rubber; indian-rubber is obtained by tapping the stem of the tree in the usual way.

Manna D. Don = Alhagi Tourn.

Mantisia Sims. Zingiberaceae. 2 sp. E. Ind. *M. saltatoria* Sims (dancing girls) is often grown in hot-houses for its curious flrs. They are borne on separate shoots springing from the rhizome. At the base is the calyx, then 3 broad petals, a curiously shaped labellum and 2 filamentous staminodes, and beyond all the fertile sta. and style.

Manulea Linn. Scrophulariaceae (II. 7). 26 sp. S. Afr.

Maoutia Wedd. Urticaceae (3). 8 sp. trop. As. and Polynes. There is no perianth in the ♀ flr. *M. Puya* Wedd. is the source of a valuable fibre.

Mapouria Aubl. Rubiaceae (II. 15). 80 sp. E. Ind., S. Am. Included in Psychotria by Benth.-Hooker.

Mappa A. Juss. = Macaranga Thou.

Maranta Plum. ex Linn. Marantaceae. 15 sp. trop. Am. The staminodes β γ (see order) are present in many sp. The rhizome of *M. arundinacea* L. furnishes West Indian arrowroot, prepared by grinding and washing to free the starch.

Marantaceae. Monocotyledons (Scitamineae). 12 gen. with 150 sp. trop., chiefly Am. Herbaceous perennials of various habit, resembling Zingiberaceae, but at once distinguishable by the presence of a swollen pulvinus or joint at the junction of petiole and leaf-blade. Leaves 2-ranked, sheathing; one side of the leaf is larger than the other and is covered by it when the leaf is rolled up in the bud. Flrs. usually upon the leafy shoots, in pairs in the axils of the bracts, either one pair or many (cymose, drepania). The flr. is asymmetric, but in each pair the one is complementary to the other (*i.e.* like its reflection in a glass). Flr. ☿, pentacyclic, 3-merous. P 3 + 3, clearly distinguished in most cases into calyx and corolla. As in the allied orders, the andrœceum is united to the corolla. There is one fertile sta., often petaloid, and round it various petaloid structures (cf. carefully Canna and Zingiberaceae). The labellum of Canna is represented by a hood-shaped leaf covering the style (Kapuzenblatt). The staminode α is represented by a more or less leathery or callous leaf (Schwielenblatt); β and γ are not always present, but are petaloid when they do occur. The same views as to the morphology of these structures have been proposed as in the case of Canna (q.v.). The inferior ovary is of (3) cpls., typically 3-loc. 3-ovuled, but commonly 2 of the loc. are abortive (as in fig.) and the third contains one ovule; ovule ana-campylo-tropous: style curved and at first enclosed in the 'Kapuzenblatt' or hood. The flr. often has an explosive mechanism. The pollen is shed upon the style, which remains held in the hood. Insects enter upon the staminode α, and in sucking honey (secreted by glands in the septa of the ovary) set free the style, which descends with a sudden shock, touching the insect's back and at the same time showering the pollen upon it (cf. Genista). The fruit is usually a loculicidal capsule. Embryo curved, in perisperm. Seed often arillate. Maranta and others furnish arrowroot, &c. *Chief genera:* Calathea, Maranta, Thalia. [Benth.-Hooker unite M. to Cannaceae, Musaceae, and Zingiberaceae to form the order Scitamineae, placed in Epigynae. Warming places it in coh. Scitamineae.]

Floral diagram of *Maranta bicolor* (modified from Eichler). $\alpha\beta\gamma$, staminodes; L., labellum (Kapuzen blatt).

Marattia Sm. Marattiaceae (11). 7 sp. trop. The synangium is oval and the compartments open by slits into a central space.

Marattiaceae. Filicineae Eusporangiatae. 4 gen. with 25 sp., trop. They are large ferns, with a stout stem rarely more than a couple of feet long, not branched (exc. Danaea), and large pinnate leaves (palmate in Kaulfussia). At the base of the leaf, which shows circinate vernation, occur a pair of stipules, which aid in bud-protection. The roots arise at the growing point, one or more to each leaf; they burrow obliquely outwards emerging some distance from the apex.

The sporangia are very numerous, and occur upon the veins on the lower side of ordinary foliage leaves. The sorus stands on a swollen placenta; in Angiopteris the component sporangia are free from one another, in the other genera they combine to form a *synangium*, with as many chambers as there are sporangia. The mode of opening varies (see classification, below). The spores are all of one kind (except that they vary in shape), and give rise to monœcious prothalli, resembling those of the ordinary ferns. These are large and may live for some years.

Classification and genera:

I. *Angiopterideae* (sporangia free): Angiopteris.

II. *Marattieae* (synangia oval): Marattia (leaf pinnate); Kaulfussia (leaf palmate with curious chambers on lower side).

III. *Danaeeae* (synangia long, opening by terminal pore): Danaea.

Marcgravia Plum. ex Linn. Marcgraviaceae. 16 sp. trop. Am. They are climbing epiphytic shrubs, with two kinds of shoots—vegetative, with two-ranked sessile leaves and clasping roots, and flowering, with stalked leaves, spirally arranged, and ending in a cymose umbel of flrs. The central flrs. are abortive and their bracts are transformed into curious pocket-like coloured nectaries with stalks. The fertile flrs. stand upside down, the infl. being pendulous, and humming-birds rub against them with their backs, while drinking honey from the nectaries.

Marcgraviaceae. Dicotyledons (Archichl. Parietales). 5 gen. with 40 sp. trop. Am. Trees or shrubs, often epiphytic, usually with pendulous infls. whose bracts are brightly coloured and transformed into nectaries. Flrs. ☿. K 4—5; C (4—5), dropping off as a cap; A 3—∞, free or united to one another and to the corolla. Ovary superior, originally 1-loc. with 2 parietal placentae; ovules ∞, anatropous; style simple. Capsule. Endosperm thin. *Chief genera:* Marcgravia, Norantea. Benth.-Hooker unite M. to Theaceae (Ternstrœmiaceae); Warming places it in Cistiflorae.

Margyricarpus Ruiz et Pav. Rosaceae (III. 9). 1 sp. Andes.

Marica Ker-Gawl. Iridaceae (II). 9 sp. trop. Am., Afr.

Mariscus Gaertn. = Cyperus Linn.

Marlea Roxb. Cornaceae. 10 sp. Indo-mal.

Marlierea Cambess. Myrtaceae (I). 50 sp. Brazil. The fruits of *M. tomentosa* Cambess. (Guapuronga) and *M. edulis* Ndz. (*M. glomerata* Berg) are eaten.

Marrubium Tourn. ex Linn. Labiatae (VI. 1). 30 sp. Eur., N. Afr., temp. As. *M. vulgare* L., white horehound, in Brit. (rare), formerly officinal.

Marsdenia R. Br. Asclepiadaceae (II. 4). 70 sp. trop. and sub-trop.

Marsilia Linn. Marsiliaceae. 30 sp. trop. and temp. The stem is a rhizome bearing leaves at the nodes, and roots on the lower side. The leaves are petiolate with four lobes, resembling those of '4-leaved clover.' They 'sleep' at night like those of Oxalis. In some sp. they are floating, on delicate petioles. Others grow in shallow water, the leaves standing erect. Some sp., *e.g. M. vestita* Hook. et Grev., vegetate during the wet season, and pass the dry in the form of sporocarps.

The sporocarp is a bean-like structure, attached to the petiole of the leaf by a stalk. It contains a number of sori, each forming a chamber reaching from the ventral to the dorsal edge of the sporocarp. In each sorus on the outer side is a placenta in the form of a ridge bearing micro-sporangia on its sides and mega-sporangia on the top.

The latter contain one spore each. The sporocarp is very hard and may remain in water a long time without showing any effect. Ultimately however, or at once if the hard shell be injured, a swelling of the mucilaginous interior tissue bursts it. "As more water is absorbed, this gelatinous inner tissue continues to expand, and forms a long worm-shaped body to which are attached a number of sori, each surrounded by a sac-shaped indusium in which the sporangia are closely packed" (Campbell). The spores are finally set free by the dissolution both of indusium and sporangium wall. The prothalli are similar to those of Salviniaceae.

The sporocarps of *M. salvatrix* Hans. (*M. Drummondii* A.Br.) are eaten by the natives of Austr., under the name nardoo.

Marsiliaceae. Filicineae Leptosporangiatae (Heterosporous). A family composed of 2 genera (Marsilia, Pilularia) with 40 sp. trop. and temp. The mature plant is aquatic or amphibious and has a thin creeping stem, growing by an apical cell, and bearing leaves at distinct nodes. The leaves are circinate in vernation like those of the ordinary ferns, but vary much in type (see genera). Roots are formed from the lower side of the stem.

The sporangia are contained in sporocarps, which are complex structures not homologous with those of the Salviniaceae. Each is the equivalent of a leaf-segment and encloses several sori, the latter composed both of micro- and mega-sporangia. Each spore is furnished with an epispore of hardened frothy mucilage. The spores pass the winter (or dry season) inside the sporangia. The subsequent stages in the life history resemble those of Salviniaceae. See genera for details.

Martynia Houst. ex Linn. (incl. *Proboscidea* Schmid.). Martyniaceae. 6 sp. trop. and sub-trop. Am. Flrs. with sensitive stigmas like those of Mimulus. The fruit has 2 long curved horns, admirably adapted for animal-distribution; for either it is carried off bodily, or else the hooks, like those of the burr of Arctium, catching passing animals cause a jerk which scatters the seeds out of the capsule.

Martyniaceae. Dicotyledons (Sympet. Tubiflorae). 2 gen. with 10 sp. trop. and sub-trop. Am., in dry or coast regions (p. 169). Herbs, often with tuberous roots, with opp. or alt. leaves, and terminal racemes of ☿, 5-merous, zygomorphic flrs. K (5); C (5); A 4 with a staminode, epipetalous, didynamous; $\underline{G}$ (2), 1-loc. with parietal placentae, and ∞ or few anatropous ovules. Capsule loculicidal, the outer pericarp soft and falling off, the inner woody; it is rendered more or less 4-loc. by the union of the T-shaped placentae together and to the endocarp. The tissue at the top of the midrib of each cpl. also becomes woody and forms a projecting spur, usually hooked at the end or curved, and serving for animal distribution. Seeds with little endosperm. *Genera:* Martynia, Craniolaria. United to Pedaliaceae by Benth.-Hooker and Warming.

Mascagnia Bert. = Hiraea Jacq.

Masdevallia Ruiz et Pav. Orchidaceae (12). 100 sp. trop. Am., Mexico. Petals small; sepals drawn out into long processes (Darwin, *Orchids*, p. 135).

Massonia Thunb. ex Linn. f. Liliaceae (V). 20 sp. S. Afr.

Matayba Aubl. = Ratonia DC.

Mathiola R. Br. = Matthiola R. Br.

Matricaria (Tourn.) Linn. Compositae (VII). 50 sp. S. Afr., Medit., Orient; 2 in Brit. (wild chamomile or feverfew), incl. *M. Chamomilla* L. (officinal).

Matthiola R. Br. Cruciferae (IV. 19). 50 sp. Medit., Eur., S. Afr. 2 in Brit. (stock) on the coasts, incl. *M. incana* R. Br., the parent sp. of the garden stock (see p. 101).

Maurandia Orteg. Scrophulariaceae (II. 5). 6 sp. Mexico. Leaf-climbers with sensitive petioles (p. 172), cultivated for their flrs.

Mauritia Linn. f. Palmae (III. 4). 9 sp. trop. Am., W. Ind. (Moriche, see Kingsley's *At Last*). They furnish wood, leaves for thatching &c., wine, fruit, fibre, &c.

Maxillaria Ruiz et Pav. Orchidaceae (27). 100 sp. trop. Am. Epiphytes.

Maximiliana Mart. Palmae (IV. 7). 3 sp. trop. Brazil.

Mayaca Aubl. Mayacaceae. 7 sp. Am.

Mayacaceae. Monocotyledons (Farinosae). Only genus Mayaca. Placed in Coronarieae by Benth.-Hooker, in Enantioblastae by Warming. See *Nat. Pfl.* for details.

Mayepea Aubl. = Linociera Sw.

Maytenus Molina. Celastraceae. 70 sp. S. Am. *M. Boaria* Molina is used as a fodder-plant, the tree being cut down.

Mazus Lour. Scrophulariaceae (II. 8). 6 sp. China to Austr.

Meconopsis Vig. Papaveraceae (II). 10 sp. N. temp. *M. cambrica* Vig., the Welsh poppy, in Brit.

Medicago Tourn. ex Linn. Leguminosae (III. 4). 50 sp. Eur., Medit., S. Afr.; 6 in Brit. (medick, nonsuch, burweed). The flr. has an explosive mechanism like Genista (q.v. and see Burkill in *Proc. Camb. Phil. Soc.* 1894). The fruit is usually twisted, often spirally coiled up into a ball or disc, and frequently provided with hooks for animal-distribution. *M. sativa* L. (lucerne or alfalfa), *M. lupulina* L., and others, are useful fodder-plants.

Medinilla Gaudich. Melastomaceae (I). 100 sp. W. Afr., As., Polynes.

Megacarpaea DC. Cruciferae (II. 5). 5 sp. Steppes. Sta. > 6 in some sp.

Melaleuca Linn. Myrtaceae (2). 100 sp. Austr. *M. Leucadendron* L. reaches into Indo-mal. region, the Philippines, &c. Its leaves yield Cajeput oil. Sta. in bundles opposite the petals. Several sp. yield oil; the timber is useful.

Melampodium Linn. Compositae (v). 25 sp. Am.

Melampyrum (Tourn.) Linn, Scrophulariaceae (III. 12). 25 sp. N. Hemisph.; 4 in Brit. (cow-wheat). Semi-parasites (see order). The flr. has a loose-pollen mechanism (p. 98 and order); the 4 anthers lie close together and form a pollen-box; the filaments of the sta. are covered with sharp teeth which ensure that a bee shall insert its proboscis down the middle line of the flr.

Melandrium Roehl. = Lychnis Linn. [*M. rubrum* Garcke = *L. dioica.*]

Melanorrhoea Wall. Anacardiaceae (I). 6 sp. Malay. *M. usitata* Wall. (Theetsee) yields a valuable black varnish, obtained by tapping the stem; the sap turns black on exposure to air.

Melanoxylon Schott. Leguminosae (II. 8). 1 sp. Brazil, *M. Brauna* Schott (Brauna). The timber is useful.

Melanthium Clayt. ex Linn. Liliaceae (I). 3 sp. N. Am.

Melastoma Burm. ex Linn. Melastomaceae (I). 40 sp. trop., exc. Afr., Am.

Melastomaceae. Dicotyledons (Archichl. Myrtiflorae). 148 gen. with 2500 sp. of trop. and sub-trop. plants, forming a very natural family, easy to recognize in most cases, even when not in flr., on account of the peculiar leaf-veining &c. The habit of the various genera differs much, as they inhabit very various soils and exist under varied conditions. Some are herbs, others trees or shrubs; some climb, usually by roots; some are epiphytes, water or marsh plants. The leaves are nearly always decussate (the stem is often 4-angled), but one leaf is generally much larger than the other (p. 47); the lesser in some cases withers away as it grows older, and drops off. The veins of the leaf, which is usually simple and entire or nearly so, diverge from the base and converge again at the apex, as in many monocotyledonous leaves, so that there is no true midrib. This peculiarity is possibly correlated with the fact that most of these plants live in rainy tropical regions, and this arrangement of the veins aids in conveying away the water from the surface of the leaf (see *Ficus religiosa* and p. 143). Many M. are myrmecophilous plants, *e.g* Tococa, Maieta, &c. (q.v.).

The infl. is cymose, but exhibits great variety. The flr. is usually very characteristic and easily recognized by the curious appendages of the anthers. The receptacle ('calyx-tube') is tubular or bell-shaped, commonly more or less united with the ovary, and very often brightly coloured. K 4 or 5; C 4 or 5, perigynous. The perianth is usually regular, but irregularity often occurs in the andrœceum. Sta. usually twice as many as petals, standing (when mature) in one whorl, bent down in bud so that the anthers come between the ovary and the receptacle. The anther-loculi open by a common apical pore. The connective is developed in various ways and usually provided with curious appendages, frequently of sickle-like form, giving a characteristic aspect to the flr. Ovary superior or inferior, usually 4—5-loc., with a simple style and stigma; ovules ∞, anatropous, on axile placentae. Fruit a berry or loculicidal capsule. Seed exalbuminous; one cotyledon larger than the other. The M. are of little economic importance; a few yield colouring matters.

Classification and chief genera (after Krasser):

A. Fruit many-seeded. Embryo very small.

I. *MELASTOMATOIDEAE* (ovules on slightly projecting placentae in inner angle of loc.): Tibouchina, Centradenia, Melastoma, Monochaetum, Medinilla, Leandra, Miconia, Tococa, Maieta.

II. *ASTRONIOIDEAE* (ovules on a placenta at base or on wall of loc.): Kibessia.

B. Fruit 1—5-seeded. Embryo large.

III. *MEMECYLOIDEAE*: Memecylon.

[Placed in Myrtales by Benth.-Hooker, in Myrtiflorae by Warming.]

Melia Linn. (incl. *Azadirachta* A. Juss.). Meliaceae. 12 sp. trop., except Am. Some are useful for their timber. *M. Azedarach* L., the Margosa, is cultivated for its flrs. The bark of *M. Azadirachta* L. (*A. indica* A. Juss.) is astringent and yields the medicinal Nim or Margosa oil.

Meliaceae. Dicotyledons (Archichl. Geraniales). 40 gen. with 600 sp. trop. and sub-trop. Most are trees and shrubs, with alt. exstip. pinnate leaves, and cymose panicles of ☿ regular flrs. K (4—5) or 4—5; C 4—5; A 8—10 usually united below into a tube, or sometimes united all their length, in which case the anthers are sessile on the tube; disc present or not; $\underline{G}$ 2—5-loc. or rarely 1-loc. or more than 5-loc.; style present or not; ovules in each loc. 1, 2, or more, usually pendulous and anatropous, with ventral raphe. Capsule, berry, or drupe; seeds often winged, with endosperm. Many, *e.g.* Swietenia (mahogany), Cedrela, &c., yield valuable timber; the seeds of several are used as sources of oils; others have edible fruit. *Chief genera:* Cedrela, Pteroxylon, Swietenia, Carapa, Melia, Aglaia, Trichilia. Placed in Geraniales by Benth.-Hooker, in Terebinthinae by Warming. [See Flindersia.]

Melianthaceae. Dicotyledons (Archichl. Sapindales). 3 gen. with 17 sp., Afr. (trop. and S.). Trees and shrubs with alt. usually stip. leaves, and racemes of ☿, median-zygomorphic flrs., whose stalks twist through 180° at the time of flowering. K 5 or (5), sometimes 4 by union of two sepals; C 4 or 5; disc extra-staminal; A 5 or 4 or 10, free or united at base; $\underline{G}$ (4—5), 4—5-loc. with one basal or many axile ovules in each loc.; ovules erect or pendulous, anatropous, with ventral or dorsal raphe according as they are erect or pendulous respectively. Capsule; seed sometimes with aril; endosperm fleshy or horny. *Chief genus:* Melianthus. United to Sapindaceae by Benth.-Hooker, placed in Aesculinae by Warming.

Melianthus Linn. Melianthaceae. 5 sp. S. Afr. The flrs. are very rich in honey.

Melica Linn. Gramineae (x). 30 sp. temp., except Austr.; 2 in Brit. (melic-grass).

Melilotus Tourn. ex Hall. Leguminosae (III. 4). 20 sp. temp. and sub-trop. Old World. 3 in Brit. (melilot). The flrs. contain much honey, and are adapted to bees.

Meliosma Blume. Sabiaceae. 45 sp. trop. As. and Am. [See Urban in *Ber. D. Bot. Ges.* XIII. 1895.]

Melissa Tourn. ex Linn. Labiatae (VI. 11). 4 sp. Eur., W. As. *M. officinalis* L. is the common balm.

Melittis Linn. Labiatae (VI. 4). 1 sp. Eur. (incl. Brit.), *M. Melissophyllum* L., the bastard-barm.

Melocactus (Tourn.) Link et Otto. Cactaceae (I. 1). 90 sp. (?) W. Ind., S. Am. Ribbed plants, like Cereus. Flrs. produced at the top of the plant.

Melochia Dill. ex Linn. Sterculiaceae. 60 sp. trop.

Melodorum Hook. f. et Thoms. Anonaceae (4). 30 sp. Old World trop.

Melothria Linn. Cucurbitaceae (II). 60 sp. trop. and sub-trop.

Memecylon Linn. Melastomaceae (III). 100 sp. trop.

Mendoncia Vell. Acanthaceae (II). 24 sp. trop. Am., Madagascar.

Meniscium Schreb. Polypodiaceae. 10 sp. trop.

Menispermaceae. Dicotyledones (Archichl. Ranales). 58 gen. with 200 sp. trop. and warm temp. Mostly climbing shrubs with alt. simple leaves, in whose axils are usually serial buds (p. 42). The stem-anatomy is of interest. Flrs. in axillary racemes (except Cissampelos, &c.), unisexual, usually diœcious. The general formula is K 3+3, C 3+3, A 3+3, $\underline{G}$ 3, but there are many exceptions. The calyx and sta. are often more than 6, and sometimes there is only 1 cpl. Ovules 1 in each cpl., ventral, pendulous, semi-anatropous. Achene; seed albuminous. The classification of the genera is largely based on the structure of the seed. A few are or have been medicinal, on account of the bitter principle in the roots. *Chief genera:* Menispermum, Cocculus, Cissampelos, Jateorhiza, Tinospora, Anamirta. Placed in Ranales by Benth.-Hooker, in Polycarpicae by Warming.

Menispermum (Tourn.) Linn. Menispermaceae. 3 sp. N. temp. (moonseed).

Mentha (Tourn.) Linn. Labiatae (VI. 11). 40 sp. temp. and trop. A very variable genus. 6 in Brit. (mint), of which *M. piperita* L. is the peppermint, *M. Pulegium* L. the penny-royal. From the former an oil is obtained by distillation and used in medicine &c. *M. viridis* L. is cultivated as a pot-herb for flavouring.

Mentzelia Plum. ex Linn. (incl. *Eucnide* Zucc.) Loasaceae. 46 sp. trop. and sub-trop. Am. They have no stinging hairs. In some sp. the outer sta. are sterile.

Menyanthes (Tourn.) Linn. Gentianaceae (II). 1 sp. *M. trifoliata* L., the buck- or bog-bean, Eur. (incl. Brit.), As., N. Am. It is a bog plant with creeping rhizome and alt. leaves. The flrs. are dimorphic heterostyled (cf. Primula). The rhizome has bitter tonic properties and was much used in former times (and is to this day in the Cambridgeshire fens).

Menziesia Sm. Ericaceae (I. 2). 7 sp. E. As., N. Am. [*M. polifolia* Juss. of some Brit. floras = *Daboecia polifolia*, and *M. caerulea* Sw. = *Bryanthus taxifolius*.]

Mercurialis (Tourn.) Linn. Euphorbiaceae (A. II. 2). 7 sp. Medit., Eur., E. As. 2 in Brit., *M. perennis* L. and *M. annua* L. (mercury). Diœcious anemophilous flrs. Vegetative propagation in perennial sp. by rhizomes. Corolla absent. Cpls. (2).

Merendera Ram. Liliaceae (I). 10 sp. Medit.

Mertensia Roth. Boraginaceae (IV. 4). 15 sp. N. temp. 1 in Brit., *M. maritima*, S. F. Gray (gromwell), on sea-coasts (p. 186).

Mesembryanthemum Dill. ex Linn. Aizoaceae (II. 3). 300 sp., almost all S. Afr. They are xerophytes of the most pronounced kind with very succulent leaves, usually closely packed together; the young leaves stand face to face at the growing apex till well grown, and thus protect the young bud. In *M. obconellum* Haw. the pairs of leaves are congenitally united into a fleshy body with a little slit in the centre. Several sp. have thorns, sometimes flr.-stalks hardened after the fall of the flr., sometimes branches, as in *M. spinosum* L. (the leafy branches appear below these in the next year, in the same axils). The flrs. are usually terminal on the stems, solitary or in dichasia or cincinni. The outer sta. (due to branching) are represented by numerous petaloid staminodes, having the appearance of a corolla. The mature ovary is 5-loc. with parietal placentae; this peculiar feature is due to an excessive growth of the peripheral tissue during the development, which gradually turns the loculi completely over (cf. Punica). The fruit is a capsule which opens only in moist air, contrary to the usual wont of capsules (p. 168). Some, *e.g. M. edule* L. (hottentot fig), contain an edible pulp. *M. crystallinum* L. is the ice-plant, so-called because its leaves are covered with small glistening bladder-shaped hairs.

Mesospinidium Rchb. f. = Odontoglossum H. B. et K.

Mespilodaphne Nees = Ocotea Aubl.

Mespilus (Tourn.) Linn. = Pyrus Tourn. [*M. germanica* L. = *Pyrus germanica*; *M. Oxycantha* Crantz = *Crataegus Oxyacantha*.]

Mesua Linn. Guttiferae (IV). 3 sp. India, Java. *M. ferrea* L. (Nagas or iron-wood) yields a valuable timber; its flrs. are used in perfumery.

Metrosideros Banks. Myrtaceae (II. 2). 20 sp. S. Afr., Sunda Is., Austr., Polynes. Some sp. furnish useful timber.

Metroxylon Rottb. Palmae (III. 5). Siam to New Guinea. *M. Rumphii* Mart. and *M. laeve* Mart. are the sago palms, cultivated all over the

Malay region. Small trees whose stems die after producing their large terminal monoecious infls. (cf. Corypha, &c.), but form rhizome branches below. The fruit takes 3 years to ripen. The tree is cut down when the infl. appears, and the sago is obtained from the pith by crushing and washing.

Meum (Tourn,) Adans. Umbelliferae (6). 1 sp. *M. athamanticum* Jacq. (meu or bald-money) in Eur. (incl. Brit., where it is sub-alpine).

Meyenia Nees = Thunbergia Retz.

Mibora Adans. Gramineae (VIII). 1 sp. W. Eur. (incl. Brit.)

Michauxia L'Hérit. Campanulaceae (I). 6 sp. Orient. Flr. 7—10-merous throughout.

Michelia Linn. Magnoliaceae (1). 13 sp. trop. As., China. There is a gynophore between sta. and cpls. *M. Champaca* L. is cultivated for its perfumed flrs. Several sp. yield useful timber.

Miconia Ruiz et Pav. (*Tamonea* Aubl.). Melastomaceae (I). 550 sp. trop. Am.

Micrembryae (Benth.-Hooker). The 4th series of Incompletae (p. 135).

Microcachrys Hook. f. Coniferae (Taxac. 3; see C. for genus characters). 1 sp. Tasmania. Dioecious. Fruit-scales fleshy but not united. Seed arillate.

Microcala Hoffmgg. et Link. Gentianaceae (I. 2). 2 sp., 1 Am., the other Medit. and W. Eur. (incl. south-west England and Ireland).

Microglossa DC. Compositae (III). 9 sp. trop. As. and Afr. The leaves of *M. volubilis* DC. are used as a vegetable and in salad.

Microlepis Miq. Melastomaceae (I). 4 sp. S. Brazil.

Microlicia. Melastomaceae (I). 100 sp. trop. Am.

Micromeria Benth. Labiatae (VI. 11). 60 sp. Medit., trop. Afr., Eur., W. As., Am. *M. Douglasii* Benth. (Calif. &c.) is the Yerba buena (medicinal).

Microseris D. Don. Compositae (XIII). 32 sp. N. Am., S. Am., Austr., N. Z.

Microspermae. The 10th cohort (Engler) of Monocotyledons (p. 126). The 1st series (Benth.-Hooker) of Monocotyledons (p. 136).

Microstylis Nutt. Orchidaceae (8). 70 sp. As., Am. Flr. twisted through 360° (cf. Malaxis).

Mikania Willd. Compositae (II). 150 sp. trop., all but one (*M. scandens* Willd.) confined to Am. Twining herbs or shrubs, with opp. leaves.

Milium Linn. Gramineae (VIII). 6 sp. N. Temp. *M. effusum* L. (millet-grass) in Brit. The leaf-blade is turned over on itself (cf. Alstroemeria).

Miliusa Leschen. Anonaceae (1). 24 sp. trop. As.

Millettia Wight et Arn. Leguminosae (III. 6). 50 sp. trop. and sub-trop. Old World.

Millingtonia Linn. f. Bignoniaceae (I). 1 sp. Further India.

Miltonia Lindl. Orchidaceae (28). 17 sp. trop. Am. Epiphytes.

Mimosa Linn. Leguminosae (I. 3). 300 sp. trop. and sub-trop. Am., a few in Afr. and As. *M. pudica* L., the sensitive plant, is now a common weed in many trop. lands and is universally cultivated in hot houses. The genus consists mainly of herbs and undershrubs, frequently with stipular thorns. *M. pudica* has a bipinnate leaf with four secondary petioles. It is exceedingly sensitive, and a touch or shake will make it move rapidly into the position which it assumes at night. The leaflets move upwards in pairs, closing against one another, the secondary petioles close up against one another and the main petiole drops through about 60°. After a short time the movements are slowly reversed. They are effected by the aid of a *pulvinus* or swollen joint at each point of movement. Each pulvinus can be made to work independently of the rest by gentle stimulation, and the propagation of the stimulus from pulvinus to pulvinus may also be seen. [For physiology of the process see text-books.] The ribs of the fruit are frequently thorny and are usually dropped on dehiscence.

Mimulus Linn. Scrophulariaceae (II. 8). 60 sp. extra-trop. Am., S. and E. As., Austr., E. Afr. Several are favourite garden plants and one of these, *M. luteus* L., the yellow monkey-flower, has become naturalised in Brit. on river-banks &c. *M. moschatus* Dougl. is the common musk-plant of cottage windows. Insects entering the flr. touch first the stigma, which is sensitive to contact and closes up, so that self-pollination by the retreating insect is prevented (cf. Martynia).

Mimusops Linn. Sapotaceae (II). 35 sp. trop. *M. Balata* Crueg. (*M. globosa* Gaertn.; Guiana) yields a gutta-percha (Balata). *M. elata* Allem. is the Brazilian milk tree or Masseranduba. The timber is hard and durable, the fruit edible, "but strangest of all is the vegetable milk, which exudes in abundance when the bark is cut; it has about the consistence of thick cream...also used for glue...as it hardens by exposure to air it becomes a tough substance resembling gutta-percha" (Wallace, *Amazon*, ch. II.).

Mina Cerv. = Ipomœa Linn. [*M. lobata* Cerv. = *I. versicolor*.]

Mirabilis Riv. ex Linn. (excl. *Oxybaphus* L'Hérit.). Nyctaginaceae (I). 10 sp. trop. Am. At the base of the flr. is an involucre of 5 leaves resembling a calyx; it is really the bracts of a 3-flowered dichasial cyme, of which in most sp. only the central flr. is developed. In some sp., however, *e.g. M. coccinea* Benth. et Hook. f., the involucre encloses more than 1 flr. The flr. opens in the evening and is protogynous (in *M. Jalapa* L. and other common garden sp.), with ultimate autogamy on withering. The involucre often forms a parachute on the fruit. The tuberous roots of *M. Jalapa* L. (false jalap, four-o'clock, marvel of Peru) were formerly used as jalap.

Mirbelia Sm. Leguminosae (III. 2). 16 sp. Austr.

Mitchella Linn. Rubiaceae (II. 17). 2 sp. N. Am. (*M. repens* L.) and Japan. Dimorphic heterostyled. The flrs. are in pairs with united ovaries. Occasionally the calyx and corolla also fuse and we have a double ovary surmounted by a 10-lobed calyx and corolla (cf. Lonicera).

Mitella Tourn. ex Linn. Saxifragaceae (I). 7 sp. N. Am., Japan. The inconspicuous greenish flrs. stand in unilateral racemes.

Mitraria Cav. Gesneriaceae (I). 1 sp. Chili.

Mitrasacme Labill. Loganiaceae. 28 sp. Austr., trop. As.

Modecca Lam. (*Adenia* Forsk.). Passifloraceae. 30 sp. trop. exc. Am.

Modiola Moench. Malvaceae (II). 1 sp. Amer., S. Afr.

Moehringia Linn. = Arenaria Rupp.

Moenchia Ehrh. = Cerastium Dill.

Mogiphanes Mart. Amarantaceae (4). 10 sp. trop. Am. Included in Alternanthera in *Nat. Pfl.*

Mohria Sw. Schizaeaceae. 1 sp. S. Afr., Madag. The sporangia are on the under side of ordinary leaves, and the margins are turned back over them (cf. Pteris).

Molinia Schrank. Gramineae (X). 1 sp. *M. caerulea* Moench, Eur. (incl. Brit.), As.

Mollugo Linn. Aizoaceae (I). 13 sp. trop., and N. Am.

Moluccella Linn. Labiatae (VI. 4). 2 sp. Medit.

Momordica (Tourn.) Linn. Cucurbitaceae (III). 25 sp. trop. [*M. Elaterium* L. = *Ecballium Elaterium*].

Monachanthus Lindl. = Catesetum Rich.

Monanthes Haw. Crassulaceae. 3 sp. Morocco, Canaries.

Monarda Linn. Labiatae (VI. 8). 6 sp. N. Am. Sta. 2. Flr. protandrous and visited by bees (and humming-birds in the red sp.). The leaves of some sp. are used medicinally in the form of tea (Oswego-tea).

Moneses Salisb. = Pyrola Tourn. [*M. grandiflora* S. F. Gray = *P. uniflora*.]

Monimia Thou. Monimiaceae. 3 sp. Madag., Mascarenes.

Monimiaceae. Dicotyledons (Archichl. Ranales). 24 gen. with 150 sp., chiefly S. trop., and esp. in the 'oceanic' floral regions (Madag., Austr., Polynes.). Shrubs and trees, with leathery evergreen leaves, usually opp., exstip., and flrs. solitary or in cymes. The axis is hollowed so that the flr. is perigynous; the flrs. are commonly unisexual and often the two sexes differ in the hollowing of the axis. Frequently the bud opens by throwing off the outer ends of the perianth-leaves as a sort of lid. Perianth simple; sta. ∞, the anthers introrse or extrorse, opening by slits or valves; cpls. usually ∞, each with 1 usually basal erect anatropous ovule. Fruit of achenes, often more or less enclosed in or borne on a fleshy receptacle. The order forms a connecting link between Lauraceae and the other Ranales, being closely allied on one side to L., on the other to Calycanthaceae. *Chief genera:* Hedycaria, Peumus, Tambourissa, Laurelia. Placed in Micrembryae by Benth.-Hooker, in Polycarpicae by Warming.

Monizia Lowe = Thapsia Linn.

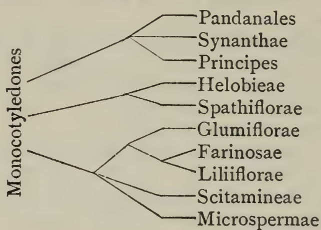
Monnina Ruiz et Pav. Polygalaceae. 60 sp. Mexico to Chili. One of the two cpls. is usually rudimentary. Fruit indehiscent.

Monochaetum Naud. Melastomaceae (1). 30 sp. W. trop. Am. Sta. dimorphous. The style, at first bent downwards, moves slowly up till horizontal.

Monochlamydeae (Benth.-Hooker). One of the chief divisions of Dicotyledons (p. 135).

Monocosmia Fenzl. Portulacaceae. 1 sp. Chili.

Monocotyledones. One of the two great divisions of Angiospermae. Their classification is less difficult than that of the Dicotyledons, and a comparison should be made of the ways in which it is done in the various systems (Ch. II.). Engler's system is based on the following genealogical tree (see his paper in *Abh. Preuss. Akad. Wiss.* Berlin, 1892, reviewed in *Beih. z. Bot. Cent.* 1893, p. 29, and in *Bot. Gazette* 1893, p. 191):



[See also Prantl, in 70 *Jahresb. d. Schles. Gesell. für vat. Cultur.*]

On the origin of M., one of the great unsolved problems in phylogeny, *cf.* Seward, *Geological History*, in *Ann. of Bot.* X, 1896, p. 205; Miss Sargant, *Theory of Origin of M.*, in *do.* XVII, 1903, p. 1.

Monodora Dun. Anonaceae (7). Fruit a berry with woody epicarp. The seeds of *M. Myristica* Dun. are sometimes used as nutmegs.

Monotropa Linn. (incl. *Hypopitys* Dill.). Pyrolaceae. 3 sp. N. temp. *M. Hypopitys* Walt., the yellow bird's-nest, is found in fir, birch and beech woods in Brit. as a yellowish saprophyte (p. 177) with scaly leaves and a short terminal raceme of flrs. Below the soil is found a very much branched root system, the roots being covered with a superficial mycorhiza by whose aid absorption takes place. Buds are formed adventitiously upon the roots and lengthen into the flowering shoots. The flrs. are homogamous, without self-fertilisation. [Monotropeae Benth.-Hooker.]

Monotropeae (Benth.-Hooker). An order in cohort Ericales, including Monotropa and its allies; placed in Pyrolaceae by Drude in *Nat. Pfl.*

Monsonia Linn. Geraniaceae. 12 sp. Afr.

Monstera Adans. Araceae (II). 15 sp. trop. Am. Climbing shrubs with curious leaves, pinnate and full of round holes. When very young the leaf is entire; then the tissue between the veins ceases to grow rapidly, becomes dry and tears away, thus leaving holes between the ribs; at the edge the marginal part usually breaks, and thus the outermost hole gives rise to a notch in the leaf, which becomes pinnated. Beginning as a climber the plant usually ends as an epiphyte with aerial roots going down to the soil. Flrs. ☿. The fruit of *M. deliciosa* Liebm. is edible.

Montbretia DC. = Tritonia Ker-Gawl.

Montia Mich. ex Linn. Portulacaceae. 1 sp. *M. fontana* L. (blinks) cosmop., exhibiting many varieties. It is an annual herb, usually found in wet places, with small cymes of flrs. These are inconspicuous and homogamous, and are probably as a rule self-fertilised. In bad weather or when submerged they become cleistogamic. The stalk goes through similar movements to that of Claytonia, and the fruit explodes in the same way. The plant is eaten as salad.

Moquilea Aubl. Rosaceae (VI. 13 a). 20 sp. S. Am. Some apetalous.

Moquinia DC. Compositae (XII). 9 sp. S. Am. Diœcious shrubs.

Moraceae. Dicotyledons (Archichl. Urticales). 55 gen. with 800 sp. trop. and sub-trop., a few temp. Most are trees or shrubs with stip. leaves, and with latex. [See Ficus, Cecropia, Maclura, Humulus.] Infl. cymose, usually taking the form of (pseudo-) racemes, spikes, umbels or heads (cf. Urticaceae, and paper there cited). Flrs. unisexual. P usually 4 or (4), persistent; sta. in ♂ as many as perianth-leaves and opp. to them, bent inwards or straight in the bud, not exploding like those of Urticaceae; G in ♀ of (2) cpls. of which one is usually aborted all but the style; ovary 1-loc. superior to inferior; ovule 1, pendulous, amphitropous with micropyle facing upwards, or rarely basal and erect. Fruit an achene or drupe-like; but commonly a multiple fruit arises by union of the fruits of different flrs., often complicated by addition of the fleshy common receptacle (see Morus, Ficus, Artocarpus). Seed with or without endosperm; embryo usually curved. Many yield useful fruits, *e.g.* Morus, Artocarpus, Ficus, Brosimum, &c.; other important economic plants are Broussonetia (paper), Castilloa (rubber), Brosimum (milk), Ficus (caoutchouc, lac, timber, &c.), Cannabis (hemp, churrus), Humulus (hop) and others.

Classification and chief genera (after Engler):

I. *MOROIDEAE* (sta. incurved in bud; ovule apical, ana- or amphi-tropous; leaves folded in bud; stipules small and not leaving an amplexicaul scar on falling): Morus, Maclura, Broussonetia, Dorstenia.

II. *ARTOCARPOIDEAE* (sta. straight; ovule as in I.; leaves convolute; stipules leaving an amplexicaul scar): Artocarpus, Castilloa, Antiaris, Brosimum, Ficus.

III. *CONOCEPHALOIDEAE* (sta. straight; ovule at base or apex, orthotropous or slightly curved; leaves &c. as in II.): Cecropia.

IV. *CANNABOIDEAE* (sta. short and straight; ovule apical, anatropous; achene; endosperm; herbs with free stipules): Humulus, Cannabis.

[Benth.-Hooker unite M. to Urticaceae (q.v.). Warming splits off sub-order IV. as an independent order Cannabaceae, placing both it and M. in Urticiflorae.]

Moraea Mill. ex Linn. Iridaceae (II). 40 sp. Afr., Austr. The outer integument of the ovule becomes fleshy as it ripens to a seed.

Moricandia DC. Cruciferae (IV. 20). 10 sp. Medit.

Morina Tourn. ex Linn. Dipsacaceae. 9 sp. E. Eur., As. Thistle-like herbs, with an infl. like that of Labiatae.

Morinda Linn. Rubiaceae (II. 19). 40 sp. trop. Flrs. in heads; the ovaries united. Several yield dye-stuffs.

Moringa Burm. The only genus of Moringaceae. 3 sp. trop. Afr., As. Trees with deciduous leaves; flrs. in racemes, zygomorphic, 5-merous. There is a cupule-like disc bearing the sta. and perianth. Ovary on a gynophore, 1-loc. with 3 parietal placentae. Capsule pod-like. Seeds winged, exalbuminous. *M. oleifera* Lam. is largely cultivated for the sake of the oil (ben-oil) obtained from the seeds.

Moringaceae. Dicotyledons (Archichl. Rhoeadales). Only genus Moringa (q.v.). It forms a connecting link to the Rosales (Leguminosae). Benth.-Hooker place it as an anomalous order at the end of Disciflorae.

Moringeae (Benth.-Hooker) = Moringaceae.

Mormodes Lindl. Orchidaceae (17). 20 sp. trop. Am., epiphytic. The flr. presents a very complex structure; the column is bent to one side, the labellum to the other. The pollinia, with their viscid disc, are violently shot out if an insect touches the articulation of the anther to the column. For details see Darwin's *Orchids* p. 208. Cf. Catasetum and Cycnoches, the other two genera of § 17.

Morus (Tourn.) Linn. Moraceae (I). 10 sp. N. temp. Flrs. monœcious or diœcious, the ♂ in catkins, the ♀ in pseudo-spikes, wind-pollinated. Each ovary gives an achene enclosed in the perianth whose leaves become completely united and fleshy. The whole mass of fruits thus produced on the one spike is closely packed together, giving a multiple fruit very like a black-berry (Rubus), but of very different morphological nature. The fruit (mulberry) is edible. The leaves of *M. alba* L. (white mulberry), *M. nigra* L. (black mulberry), and others are used for feeding silkworms.

Mucuna Adans. Leguminosae (III. 10). 30 sp. trop. and sub-trop. Some sp. have stinging hairs on the pods.

Muehlenbeckia Meissn. Polygonaceae (III. 5). 15 sp. Austr. to S. Am. *M. platyclados* Meissn. has phylloclades (p. 166), flat and green, with transverse bands at the nodes, and green leaves which drop off early. Flrs. polygamous or diœcious.

Muehlenbergia Schreb. Gramineae (VIII). 60 sp. N. Am., Andes, Japan, Himal. Some are useful fodder-grasses.

Mulgedium Cass. = Lactuca Tourn.

Multiovulatae Aquaticae and **M. Terrestres** (Benth.-Hooker). The 2nd and 3rd series of Incompletae (p. 135).

Muraltia Neck. Polygalaceae. 40 sp. S. Afr.

Murraya Koen. ex Linn. Rutaceae (x). 4 sp. Indo-mal. The timber is useful, and the leaves are used as a condiment by the Hindoos.

Musa Linn. Musaceae. About 20 sp. trop., exc. Am. Large herbs with rhizomes and 'false' aerial stems (see order). The infl. springs from the rhizome and emerges at the top of the aerial 'stem.' Flrs. ∞, in the axils of leathery, often reddish-coloured bracts, the fruit-forming ♀ flrs. at the base of the infl. The sepals and two anterior petals are joined into a tube, the posterior petal is free; there are 5 fertile sta., except in *M. Ensete* J. F. Gmel. where the posterior sta. is also fertile; the ovary is 3-loc., with ∞ anatropous ovules. Fruit a longish berry. Seeds with mealy perisperm. *M. Sapientum* L., the banana, with its subsp. *M. paradisiaca* L., the plantain or pisang, is one of the most important food-plants in existence, and is everywhere cultivated in the tropics, yielding 40 times as much food per acre as even the potato. The cultivated forms are propagated entirely from the rhizomes and produce no seeds (cf. Citrus). The dried fruits are ground to form plantain-meal. The stalk of the infl. of *M. Ensete* (Abyss.) is cooked and eaten. The leaf-stalks of *M. textilis* Née (Philippines &c) furnish a useful fibre, known as Manilla hemp. [For details of economic uses, &c., see *Kew Bulletin*, Aug. 1894.]

Musaceae. Monocotyledons (Scitamineae). 4 gen. with 60 sp. trop. They are (except Ravenala) gigantic herbs with rhizomes from which the leaves spring; the sheaths of the leaves are rolled round one another below, and form what looks like an aerial stem, attaining in the banana many yards in height. The leaf is large and oval, with a stout midrib, and parallel veins running from it to the edge. The edge is easily torn between the bundles, as they do not join in the same way as in a Dicotyledon; and so the wind and rain soon reduce the leaf to a very ragged condition. The flrs. are in cymes or racemes with large brightly coloured bracts or spathes; they are usually ☿ and zygomorphic, but come much nearer to the usual type of Monocotyledonous flr. than do those of the other orders of Scitamineae (q.v.). P 3 + 3, free or united in various ways, both whorls petaloid; A 3 + 2, the posterior sta. of the inner whorl being represented by a staminode; $\overline{G}$ (3), 3-loc., with 1—∞ ovules in each loc. Fruit a berry, capsule, or schizocarp. Seed with straight embryo and mealy perisperm. The flrs. are rich in honey, and are visited by bees and birds. Musa is an important economic genus.

Classification and genera: the M. are closely related to the other Scitamineae to which they are joined by Benth.-Hooker, and less closely to the Liliiflorae on one hand and the Orchids on the other.

1. *Museae* (odd sepal anterior; ovules ∞ in each loc.): Ravenala, Strelitzia, Musa. Old World (exc. 1 sp. of Ravenala).
2. *Heliconieae* (odd sepal posterior; ovules 1 per loc.): Heliconia. Confined to America.

Muscari Tourn. ex Mill. Liliaceae (V). 40 sp. Medit., Eur., As. *M. racemosum* Mill. (grape-hyacinth) in Brit. The upper flrs. of the raceme are neuter, serving only to give extra conspicuousness to the infl. (cf. *Centaurea Cyanus*); the lower are homogamous and bee-visited.

Mussaenda Burm. ex Linn. Rubiaceae (I. 7). 30 sp. trop. (exc. Am.). One sepal is large, leafy, and brightly coloured, and helps to make the flr. conspicuous (cf. Euphorbia, Salvia).

Musschia Dum. Campanulaceae (I. 1). 2 sp. Madeira (p. 148). The capsule opens by many transverse slits betwen the ribs.

Mutisia Linn. f. Compositae (XII). 50 sp. S. Am. Many are climbers (a rare habit in C.) with the ends of the leaf-midribs prolonged into tendrils. All are shrubs with large heads of flrs.

Myanthus Lindl. = Catasetum Rich.

Myoporaceae. Dicotyledons (Sympet. Tubiflorae). 5 gen. with 86 sp. chiefly Austr. and neighbouring Is. (1 sp. in each of the following areas:—Sandw. Is., E. As., Mauritius, Afr., W. Ind.). Most are trees or shrubs, with alt. or opp. entire exstip. leaves, which are often covered with woolly or glandular hairs, and frequently very reduced in size. Flrs. solitary, or in cymose groups, axillary, ☿, regular or zygomorphic. K (5), C (5), A 4, didynamous; anther loculi confluent. $\underline{G}$ (2), 2-loc. or by segmentation 3—10-loc., in the former case with 1—8, in the latter with 1, ovule in each loc. Ovule pendulous, anatropous. Drupe. Endosperm. *Chief genera:* Pholidia, Myoporum. Placed in Lamiales by Benth.-Hooker, in Labiatiflorae by Eichler (see *Blüthendiag.*).

Myoporineae (Benth.-Hooker) = Myoporaceae.

Myoporum Banks et Soland. Myoporaceae. 25 sp. Austr., E. As., Sandw. Is., Mauritius. *M. laetum* Forst. f. (N. Z.) yields useful timber.

Myosotidium Hook. Boraginaceae (IV. 1). 1 sp. Chatham Is. (p. 148).

Myosotis Linn. Boraginaceae (IV. 4). 30 sp. Old World temp. 8 in Brit. (scorpion-grass, forget-me-not). The corolla-mouth is nearly closed by scales, and in some sp. there is a coloured ring at the entrance forming a honey guide (see Life of Sprengel, in *Nat. Science* Apr. 1893). The colour of the corolla changes as it grows older (see order).

Myosurus Linn. Ranunculaceae (3). 5 sp. temp. *M. minimus* L. (mouse-tail) in Brit. The receptacle is much elongated

Myrcia DC. Myrtaceae (1). 190 sp. trop. Am.

Myrica Linn. Myricaceae. 40 sp. Eur., As., Afr., Am., esp. sub-trop. *M. Gale* L., the sweet gale or bog-myrtle, is frequent in Brit. in mountain bogs. Its leaves have a pleasant resinous smell when rubbed or on hot days. The flrs. are in short catkins, achlamydeous. The ♂ has usually 2 bracteoles and 4 sta. (2—16); the ♀ 2—4 bracteoles and 2 syncarpous cpls. with one erect orthotropous ovule. The fruit is a nut, the exocarp secreting wax. *M. cerifera* L. (N. Am., wax-myrtle or bay-berry) and other sp. are used as sources of wax, to procure which the fruits are boiled.

Myricaceae. Dicotyledons (Archichl. Juglandales). Only genus Myrica (q.v.). Placed in Unisexuales by Benth.-Hooker, in Juglandiflorae by Warming.

Myricaria Desv. Tamaricaceae. 10 sp. Scandinavia to China.

Myriocarpa Benth. Urticaceae. 6 sp. trop. Am. Flrs. ∞, in catkins.

Myriophyllum Ponted. ex Linn. Haloragidaceae. 18 sp. cosmop.; 2 in Brit. (water milfoil). Water plants, submerged, with usually whorled much-divided leaves, borne on shoots that spring from the rhizome-like stems creeping on the ground. Land forms are occasionally produced in some sp. The infl. projects above water; and the flrs. are wind-fertilised. Hibernation by winter-buds as in Utricularia. [See p. 159.]

Myristica Linn. Myristicaceae. 80 sp. trop., esp. As. Trees with 2-ranked exstip. evergreen leaves and diœcious regular flrs. P (3), simple (cf. Monodora); A (3—18), extrorse; $\underline{G}$ 1, with 1 basal anatropous ovule. The fruit is a berry, but splits by both sutures, disclosing a large seed—the nutmeg—with a curious branched red aril—the mace—around it. Endosperm ruminate. The nutmeg of commerce is the seed of *M. fragrans* Houtt. (*M. moschata* Thunb.), a native of the Moluccas.

Myristicaceae. Dicotyledons (Archichl. Ranales). Only genus Myristica (q.v.). Placed in Micrembryae by Benth.-Hooker, in Polycarpicae by Warming. [See Warburg in *Bot. Cent.* 64, p. 204.]

Myrmecodia Jack. Rubiaceae (II. 15). 18 sp. Indo-mal. Epiphytes with leafy stems. The base of the stem forms a large tuber fastened to the support by adventitious roots. The tuber presents a very remarkable structure, being composed of a large mass of tissue, chiefly cork, penetrated by numerous communicating galleries and chambers, which are inhabited by ants. These galleries are formed in a peculiar way; after germination the hypocotyl swells into a small parenchymatous tuber, and in this, in an axial direction, there appears a hollow cylinder of phellogen (p. 158) which proceeds to form cork on its *inner* side and parenchyma on the outer, thus adding to the bulk of the tuber and at the same time forming in it a hollow space (for the tissue within the cylinder of cork dies and dries up) open to the surface. Near the outer surface of the tuber is a phellogen layer acting in the ordinary way, forming a bark. As the tuber grows more phellogens appear like the first, adding more parenchyma and forming new cavities which are always in communication with the old. It has not been proved that the ants are of any service to the plant, so that it remains very doubtful whether M. is a truly myrmecophilous plant (see Acacia, Cecropia). The tuber seems rather to be a water-storage apparatus (p. 175). [See Goebel's *Pflanzenbiol. Schild.*, Treub in *Ann. Buitenz.* III. and VII., Karsten, in do. XII.]

Myrothamnaceae. Dicotyledons (Archichl. Rosales). An order allied to Cunoniaceae, chiefly noteworthy for the dioecious achlamydeous flrs., which are apparently wind-fertilised. The only genus is Myrothamnus. Placed in Hamamelidaceae by Benth.-Hooker.

Myrothamnus Welw. Myrothamnaceae. 2 sp. S. Afr. and Madag.

Myroxylon Forst. (*Xylosma* Forst. f.). Flacourtiaceae. 45 sp. trop. (exc. Afr.).

Myroxylon Linn. f. = Toluifera Linn. (same specific names).

Myrrhis (Tourn.) Linn. Umbelliferae (5). 4 sp. Eur., W. As., N. Am. *M. odorata* Scop. in Brit. (sweet cicely or myrrh), sometimes used as a pot-herb.

Myrsinaceae. Dicotyledons (Sympet. Primulales). 23 gen. with 550 sp., chiefly trop. and subtrop.; a few sp. reach Cape Col., N. Z. and Florida. They are shrubs and trees with alt. leaves, often in rosettes. In some (e.g. Theophrasta, q.v.) the young twigs are covered with thorny scales. The leaves are usually leathery, entire, exstip., with resin-passages in their tissues. Flrs. solitary (Deherainea) or in racemose infls., with 2 bracteoles, ☿ or unisexual, actinomorphic, 4- or 5-merous. K (5); C (5); A 5, epipetalous and opp. to the petals; anthers introrse or extrorse; staminodes sometimes present, alt. with petals. G superior, rarely inf. or semi-inferior, 1-loc.; placenta basal or free-central with few or ∞ ovules, semi-anatropous or semi-campylotropous, sunk in placentar tissue. Style and stigma simple. As the fruit ripens, most of the ovules usually abort, and there results a one- or few-seeded drupe. Embryo straight or slightly curved; endosperm fleshy or horny.

Classification and chief genera (after Pax): the M. are closely allied to Primulaceae, being distinguished chiefly by the habit and the fruit. They also approach Sapotaceae, but the latter have a chambered ovary.

A. Anther loculaments not chambered:

I. *THEOPHRASTOIDEAE* (Ovary sup. Staminodes): Theophrasta, Jacquinia, Clavija, Deherainea.

II. *MYRSINOIDEAE* (Ovary sup. No staminodes): Embelia, Myrsine, Ardisia.

III. *MAESOIDEAE* (Ovary inf. or semi-inf.): Maesa.

B. Anther loculaments transversely chambered.

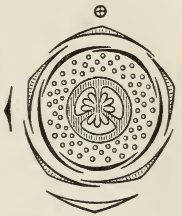
IV. *AEGICERATOIDEAE*: Aegiceras.

[Placed in Primulales by Benth.-Hooker, in Primulinae by Warming.]

Myrsine Linn. Myrsinaceae (11). 80 sp. trop. As. Afr.

Myrsiphyllum Willd. = Asparagus Tourn.

Myrtaceae. Dicotyledons (Archichl. Myrtiflorae). 72 gen. with about 2000 sp., trop. and sub-trop.; the chief centres of distribution are Austr. (*Leptospermoideae*) and trop. Am. (*Myrtoideae*). They are trees and shrubs, varying in size from a small creeper to the giant Eucalyptus, with oil-glands in leaves &c. Leaves usually opp., exstip., evergreen, entire. Flrs. generally in cymes, ☿, regular. The receptacle is more or less hollow and united to the ovary. In Metrosideros and most of its allies the union is not very complete, but in the rest of the order it is complete, and the flr. is epigynous. K (4—5) or 4—5, in some genera not opening when the flr. opens, but thrown off as a lid, usually quincuncial, with the second leaf posterior; C 4—5, the petals often nearly circular; $A\infty$, free, rarely definite usually bent inwards in bud; $\bar{G}\ \infty$—1-loc., with 2—∞ anatropous or campylotropous ovules in each loc.; style and stigma simple; placentae usually axile, rarely parietal. Fruit a berry, drupe, capsule, or nut. Seeds with no endosperm. Several M. are economically important, *e.g.* Eucalyptus (timber, kino, oil), Eugenia (cloves &c.), Psidium (guava), &c.



Floral diagram of *Myrtus communis* (after Eichler).

Classification and chief genera:

I. *MYRTOIDEAE* (berry, rarely drupe):

1. *Myrteae*: Myrtus, Psidium, Pimenta, Eugenia, Syzygium.

II. *LEPTOSPERMOIDEAE* (dry fruit):

2. *Leptospermeae* (ovary multi-loc.): Metrosideros, Eucalyptus, Callistemon, Melaleuca.
3. *Chamaelaucieae* (1-loc.; 1-seeded nut): Darwinia.

[Benth.-Hooker unite Lecythidaceae to M. and place it in Myrtales; Warming adds to M. both L. and Punicaceae, placing it in Myrtiflorae.]

Myrtales (Benth.-Hooker). The 12th cohort of Polypetalae (p. 134).

Myrtiflorae. The 22nd cohort (Engler) of Archichlamydeae (p. 130). The 22nd cohort (Warming) of Choripetalae (p. 137).

Myrtus (Tourn.) Linn. (incl. *Ugni* Turcz.). Myrtaceae. 70 sp. trop. and subtrop. *M. communis* L., the myrtle, is a W. As. shrub, long naturalised in Eur. The Chilian sp. (§ *Ugni*) have edible fruits.

Mystacidium Lindl. Orchidaceae (31). 20 sp. Afr.

Myzodendraceae. Dicotyledons (Archichl. Santalales). Only genus Myzodendron. United to Santalaceae by Benth.-Hooker and Warming. See *Nat. Pfl.*

Myzodendron (Banks) Soland. Myzodendraceae. 7 sp. Chili, Patagonia. Semi-parasitic green shrubs (p. 176), like Loranthaceae.

Naegelia Regel (*Smithiantha* O. Ktze.). Gesneriaceae (II). 6 sp. Mexico; several are favourite stove plants. They form subterranean runners, covered with scaly leaves.

Nageia Gaertn. = Podocarpus L'Hérit.

Naiadaceae. Monocotyledons (Helobieae). Only genus Naias (q.v.). As defined by Benth.-Hooker the order includes a number of plants here placed in different orders, viz. Potamogetonaceae, Naiadaceae, Aponogetonaceae, and Juncaginaceae.

Najas Linn. Naiadaceae. 15 sp. cosmop.; 2 in Brit. Freshwater annual plants, submerged, with slender stems and opp. usually toothed linear leaves. Flrs. diclinous; the ♂ consists of a single anther, which is terminal on the axis (see Goebel's *Entwicklungsgeschichte der Planzenorgane* p. 278) and 1- or 4-loc., enclosed in two sheathing perianths; the ♀ flr. consists of an ovary of one cpl., naked or surrounded by a perianth-like organ. Pollination occurs under water as in Zostera, but the pollen is spherical. Ovule 1, anatropous, terminal on the axis. Embryo straight; no endosperm. [See *Nat. Pfl.* and Eichler's *Blüthendiag.*]

Nama Linn. Hydrophyllaceae. 27 sp. Am., Sandwich Is.

Nandina Thunb. Berberidaceae. 1 sp., *N. domestica* Thunb., China, Japan. The perianth (including 2 whorls of honey leaves) is in 9 whorls, showing a more petaloid structure as they near the centre.

Napaea Linn. Malvaceae (II). 1 sp. N. Am. Dioecious.

Napoleona Beauv. Lecythidaceae. 7 sp. W. trop. Afr. The flr. has a certain resemblance to that of Passiflora, owing to the corona of staminodes. Ovary 5—20- loc. Berry.

Narcissus (Tourn.) Linn. Amaryllidaceae (I). 40 sp., Eur., Medit., As. Several are favourites in horticulture, *e.g. N. Pseudo-narcissus* L., the daffodil, *N. poeticus* L. the poet's Narcissus, *N. Jonquilla* L., the jonquil, *N. Tazetta* L., and others. The corona is well developed, and free from the stamens (see order).

Nardostachys DC. Valerianaceae. 2 sp. Himal. *N. Jatamansi* DC., the spikenard, has very fragrant rhizomes.

Nardus Linn. Gramineae (XII). 1 sp. Eur., W. As., *N. stricta* L., the nard or mat-grass, common on moors in Brit. The infl. is markedly unilateral (an unusual feature in § XII). The grass is of no feeding value.

Narthecium Moehr. Liliaceae (I). 4 sp. N. temp.; *N. ossifragum* Huds. (bog-asphodel), abundant on wet moors in Brit. It has a sympodial rhizome and isobilateral leaves (the xerophytic structure is rendered necessary by the coldness of the soil, which checks absorption). The flr. is conspicuous, but contains no honey (p. 88).

Narthex Falc. = Ferula Tourn. *N. Asafoetida* Falc. = *F. Narthex.*

Nassauvia Comm. ex. Juss. Compositae (XII). 40 sp. Andes.

Nasturtium Linn. Cruciferae (II. 11). 50 sp. cosmop.; 4 in Brit., including *N. officinale* R.Br., the water-cress. In the perennial sp.

buds arise at the base of the year's shoot, and take root while still attached to the parent shoot. The adventitious roots are said to arise exogenously (p. 38). [The N. of gardens is really Tropaeolum.]

Nauclea Linn. Rubiaceae (I. 6). 30 sp. trop. As., Polynes. Flrs. in spherical heads. In *N. lanceolata* Blume (*N. purpurea* Roxb.) there are hollow swollen portions of the stem, just below the infls., inhabited by ants (cf. Acacia).

Nectandra Roland. Lauraceae (I). 70 sp. trop. and subtrop. Am.

Neea Ruiz et Pav. Nyctaginaceae (2). 30 sp. trop. S. Am. The leaves of *N. theifera* Oerst. (Caparrosa) are used as tea, and also yield a black dye.

Negundo Moench. Aceraceae. 4 sp. N. temp. Like Acer (q.v.), to which it is united in *Nat. Pfl.*

Neillia D. Don. Rosaceae (I. 1). 3 sp. Himal., S. China.

Nelsonia R. Br. Acanthaceae (I). 1 sp. trop. Old World.

Nelumbium Juss. Nymphaeaceae (I). 2 sp., *N. luteum* Willd., Pennsylvania to Columbia, and *N. speciosum* Willd. (*N. nuciferum* Gaertn.) Japan to Caspian and N.E. Austr. The latter sp. is the sacred Lotus, no longer however found in the Nile. Sculptures of it are common in Egyptian temples, and it is still regarded as sacred in India, Tibet, China, &c. Both sp. are marsh plants; the fls., which are very large and handsome, and the big peltate slightly hairy leaves stand above the water (do not float upon it, as from analogy we should expect). The rhizome bears 'triads' of leaves; after a long internode comes a scaly-leaf on the lower side, then one on the upper side, immediately followed by a foliage-leaf with ochreate stipule, then a long internode again, and so on. This peculiar leaf-arrangement is quite unique. From the axil of the second scale-leaf springs the flr., from that of the foliage-leaf a branch. The flr. has no bracteoles. The first perianth-leaf is anterior, the second posterior, then follow 2 lateral; these 4 are sometimes regarded as a calyx. They are followed by numerous petals and sta., acyclically arranged. In the centre of the flr. stands the curious obconical gynœceum, consisting of a large number of cpls. embedded separately in the top of the swollen receptacle. Each cpl. contains 1 pendulous ovule. The receptacle becomes dry and very light, and the achenes separate from it, as the fruit ripens. It breaks off bodily from the stalk and floats about until decay sets free the fruits, which sink to the bottom of the pond. There is no endosperm or perisperm. The seeds of *N. speciosum* are used as food in Cashmere &c.

Nelumbo (Tourn.) Adans. = Nelumbium Juss.

Nemastylis Nutt. Iridaceae (II). 10 sp. Am.

Nemesia Vent. Scrophulariaceae (II. 5). 24 sp. S. Afr.

Nemophila Nutt. Hydrophyllaceae. 11 sp. N. Am., often cultivated. Floral mechanism &c. as in Phacelia.

Nenuphar Link = Nuphar Sm.

Neotinea Rchb. f. = Habenaria Willd.

Neottia Linn. Orchidaceae (4). 3 sp. temp. Eur. and As.; *N. Nidus-avis* Rich. (bird's-nest orchis) in Brit. It is a leafless saprophyte (p. 177), the rhizome giving off a great number of roots which form a nest-like mass in the humus, and have endotropic mycorhiza. The older roots may throw off their root-caps and develope into shoots (cf. Anthurium). Flr. as in Listera (Darwin's *Orchids*, p. 125).

Nepenthaceae. Dicotyledons (Archichl. Sarraceniales). Only genus Nepenthes (q.v.). Placed in Multiovulatae Terrestres by Benth.-Hooker, in Cistiflorae by Warming.

Nepenthes Linn. Nepenthaceae. 40 sp. Indo-mal., Madag. (pitcher plants). Most are herbs growing in boggy places and climbing over other plants by aid of tendrils, which form prolongations of the leaf-midribs. The end of the tendril developes as a rule into a pitcher, with a lid projecting forwards over the mouth, but not closing it except in the young state. The pitcher developes by an invagination of the upper surface of the tip of the leaf; the tip takes no part in the development, and the lid grows out below it. The edge of the pitcher is curved inwards; at the entrance there are numerous honey-glands, and for some distance below it are other glands, sunk in little pits on the inner surface of the pitcher. Insects attracted by the honey (and often by the bright colour of the pitcher) gradually work their way downwards among the glands, and presently get upon the slippery lower part and ultimately into the water in the bottom of the pitcher, where they are drowned. The plant absorbs the products of their decay, but whether it secretes a ferment that acts upon the proteids, as that of Drosera does, is still an open question.

Many sp. are epiphytic. In *N. ampullaria* Jack there are two kinds of leaves (cf. Cephalotus), some with tendrils and no pitchers; others, as stalked pitchers arranged in a radical rosette.

Flrs. diœcious, regular, in racemes or with the secondary branching cincinnal; there are no bracts. P 2 + 2; in the ♂ flr. sta. (4—16) in a column; in the ♀ flr. $\underline{G}$ (4), 4-loc.; ovules ∞, anatropous, in many rows. Capsule leathery, loculicidal. Seeds light with long hair-like processes at the ends; embryo straight, in fleshy endosperm. Many sp. and hybrids are in cultivation. [See Goebel's *Pflanzenbiol. Sch.*, Macfarlane in *Ann. of Bot.* III. and VII., and cf. p. 177 and Sarracenia, Cephalotus.]

Nepeta Riv. ex Linn. (incl. *Glechoma* Linn). Labiatae (VI. 3). 100 sp. extratrop., Old World. *N. Glechoma* Benth. (ground-ivy) and *N. Cataria* L. (cat-mint) in Brit. The flrs. are markedly gynodiœcious (p. 68).

Nephelium Linn. (excl. *Litchi* Sonner.). Sapindaceae (1). 22 sp. Indo-mal. *N. lappaceum* L., the Rambutan, is largely cultivated for its fruit (like that of Litchi, q.v.). *N. Longana* Cambess., the Longan, and others, are also used. [For *N. Litchi* Cambess. see Litchi.]

Nephrodium Rich. Polypodiaceae. 250 sp. cosmop. There are 7 Brit. sp., often classed under Aspidium or Lastrea. N. has kidney-shaped indusia, while A. has peltate. The best known is *N. Filix-mas* Rich., the common shield-fern. It has a stout, nearly erect rhizome with large pinnate leaves. Branches arise on the leaf bases, but rarely. *N. Filix-mas* var. *cristatum* Moore exhibits apospory, (see Filicineae Leptosporangiatae).

Nephrolepis Schott. Polypodiaceae. 7 sp. trop. They produce runners like Strawberry, but not axillary, which take root and give rise to new plants.

Nephthytis Schott. Araceae (VI). 2 sp. trop. W. Afr.

Neptunia Lour. Leguminosae (I. 4). 8 sp. trop. and subtrop. *N. oleracea* Lour. is found in hot-houses. It has a floating stem, rooting at the nodes, and covered by a curious aerenchyma tissue (p. 161). The leaves are sensitive like those of Mimosa. The flrs. are in heads, the lower ones being ♂, or neuter with petaloid staminodes.

Nerine Herb. Amaryllidaceae (I). 10 sp. Cape Colony.

Nerium Linn. Apocynaceae (II. 4). 3 sp. Medit. to Japan. *N. Oleander* L. is the oleander. It has curious pits on the lower surface of the evergreen leaves, in which the stomata are sunk (several in each) and covered with hairs, thus reducing transpiration. The flrs. are suited to long-tongued moths.

Nertera Banks et Soland. Rubiaceae (II. 17). 6 sp. Andes, N.Z., Austr., Sandw. Is., Malaya.

Nesaea Comm. ex Juss. Lythraceae. 27 sp. Afr., Austr., As., N. Am.

Neslia Desv. Cruciferae (IV. 14). 1 sp. Eur., As.

Nestlera Spreng. Compositae (IV). 10 sp. Cape Colony.

Neurada Linn. Rosaceae (IV. 11). 1 sp. Medit. to E. Ind.

Nicandra Adans. Solanaceae (I). 1 sp. Peru, *N. physaloides* Gaertn. Ovary divided in an irregular way by the placentae. Berry nearly juiceless and with ∞ seeds, enclosed in the enlarged calyx.

Nicotiana Linn. Solanaceae (IV). 40 sp. Am., Polynes., 1 Austr. *N. Tabacum* L., cult. in warm countries, is the tobacco; the leaves are gathered and slowly dried, then packed in heaps and fermented slightly. *N. rustica* L. and others, are also used.

Nidularium Lem. = Karatas Adans.

Nierembergia Ruiz et Pav. Solanaceae (IV). 20 sp. extratrop. Am.

Nigella (Tourn.) Linn. Ranunculaceae (2). 16 sp. Medit., often cultivated as ornamental plants (love-in-a-mist, devil-in-a-bush). Annual herbs. Alternating with the calyx is an involucre of 5 leaves. Within the coloured calyx are 5—8 nectaries, curious pocket-like structures with lids which prevent small insects from reaching the honey. The cpls. are more or less completely united but have separate styles; they give rise to a capsular fruit. The flr. is protandrous; the styles at first stand straight up out of reach of the sta., but later on bend downwards over the nectaries.

Nigritella Rich. = Habenaria Willd. [See *Alpenblumen*, p. 66.]

Nipa Thunb. Palmae (V). 1 sp., *N. fruticans* Thunb., trop. Old World, a low-growing palm with monœcious infl. Fruits woody, combined into a dense head; each contains one seed. It grows in brackish water and is a very characteristic plant upon large areas of the trop. coasts (p. 191). [See Phytelephas.]

Nivenia Vent. = Aristea Soland.

Nolana Linn. Nolanaceae. 20 sp. Chili, Peru. Many are shore plants (p. 169) with fleshy leaves. The length of the sta. and style varies considerably in different flrs. (see Darwin's *Forms of Flrs.* p. 261).

Nolanaceae. Dicotyledons (Sympet. Tubiflorae). 3 gen. with 30 sp., W. coast of S. Am. Herbs or low shrubs with simple leaves, often covered with glandular hairs. The leaves in the vegetative region are alt., but in the infl. portion they become paired in the same way as in Solanaceae (q.v.). Many of the order are sea-shore plants with fleshy leaves (p. 169). Flrs. solitary in the leaf-axils, ☿, regular. K (5); C (5); A 5, alt. with petals. Cpls. typically 5, only united in Alona, usually free and divided by irregular longitudinal constrictions into 5 or 10 portions standing in a row, or by longitudinal and transverse constrictions into 10—30 portions in 2 or 3 rows. The fruit consists of a corresponding number of 1—7-seeded nutlets. Stipe 1. Seed albuminous. *Genera:* Nolana, Alona, Dolia. United to Convolvulaceae by Benth-Hooker; placed in Personatae by Warming.

Nolina Michx. Liliaceae (VI). 10 sp. South-west of N. Am. Xerophytes with the habit of Dasylirion.

Nonnea Medic. Boraginaceae (IV. 3). 30 sp. Medit.

Nopalea Salm-Dyck. Cactaceae (II). 3 sp. Cent. Am. Very similar to Opuntia. *N. coccinellifera* Salm-Dyck is the plant upon which the cochineal insect (*Coccus cacti*) is cultivated, chiefly in the Canaries &c. It has no thorns.

Norantea Aubl. Marcgraviaceae. 14 sp. trop. Amer. All the flrs. are fertile, and have saccate nectariferous bracts. The plant resembles Philodendron in habit. Placed in Ternstroemiaceae by Benth.-Hooker.

Nothochlaena R. Br. Polypodiaceae. 30 sp. trop. and temp.

Nothofagus Blume = Fagus Tourn.

Nothopanax Miq. = Panax Linn.

Nothoscordum Kunth. Liliaceae (IV). 10 sp. China, Am. Adventitious embryos are formed by budding of the nucellus tissue round the embryo-sac (cf. Funkia).

Nuculiferae (Warming). The 6th cohort of Sympetalae (p. 137).

Nudiflorae (Benth-Hooker). The 5th series of Monocotyledons (p. 136).

Nuphar Sibth. et Sm. Nymphaeaceae (III). 7. sp. N. Hemisph. *N. luteum* Sibth. et Sm. is the common yellow water-lily or brandybottle; *N. pumilum* DC. is also found in Brit. The vegetative habit is that of Nymphaea (q.v.). The flr. projects a little above the water, and is fully hypogynous. At the base of the peduncle is a rudimentary bract. There are 5 large coloured outer perianth leaves, quincuncial, the fourth being anterior. Within these are the 'petals,' 13 in number arranged in a 5/13 spiral. Then follow ∞ sta., the outer 13 alternating with the petals, the next 13 with them, and so on in a spiral. In the centre is the superior gynœceum, syncarpous, with 10—16 loculi. Stigmas, ovules, &c., as in Nymphaea. The fruit is a large berry; it breaks off from the stalk and splits up into separate cpls. The seeds have no aril like those of Nymphaea, but the slimy pericarp contains air bubbles: the seeds are set free by its gradual decay, and sink to the bottom.

Nuttallia Torr. et Gray. Rosaceae (v. 12). 1 sp. N. W. Am. Like Prunus, but with 5 free cpls.

Nyctaginaceae. Dicotyledons (Archichl. Centrospermae). 20 gen. with 160 sp., mostly trop. and esp. Am. Trees, shrubs or herbs with opp. (often unequal) leaves and no stipules. Flrs. in cymes, ☿ or unisexual, and presenting much variety in structure. At the base of the flrs. are usually several bracts, often large and coloured. In Bougainvillaea 3 large conspicuous bracts enclose a group of 3 flrs. In Abronia the number of bracts and flrs. is larger, while in Mirabilis there is only one flr. and the involucre resembles a calyx. P usually (5), petaloid, persistent upon the ripe fruit; usually the upper part drops away and the fruit remains in the lower part, which is termed the *anthocarp*, and may become glandular, or form an umbrella-like wing, or otherwise serve for seed-dispersal. Sta. typically 5, alt. with the perianth, but often 3, 8, 10 or other numbers, or raised to 20 or 30 by branching; filaments often of unequal length. Ovary of 1 cpl., superior, with a long style and 1 basal erect ana-campylotropous ovule. Fruit an achene enclosed in the perianth. The N. are of slight economic value; see Mirabilis, Neea, &c.

Classification and chief genera after Heimerl):

A. Ovary glabrous: style present; sta. 1—30.

1. *Mirabileae* (perianth enlarging after fertilisation; shrubs and herbs; ☿): Mirabilis, Allionia, Bougainvillaea, Abronia.
2. *Pisonieae* (as 1 but shrubs and trees; 1-sexual): Pisonia, Neea.
3. *Boldoeae* (perianth not enlarging; herbs; ☿): Boldoa.

B. Ovary hairy; no style: sta. 2—3.

4. *Leucastereae:* Leucaster, Reichenbachia.

[Placed in Curvembryae by Benth.-Hooker and Warming. See art. Caryophyllaceae for relationships.]

Nyctagineae (Benth.-Hooker) = Nyctaginaceae.

Nycterinia D. Don = Zaluzianskya F. W. Schmidt.

Nymphaea (Tourn.) Linn. (*Castalia* Salisb.). Nymphaeaceae (III). 32 sp. trop. and temp. *N. alba* L., the white water-lily, in Brit. Many sp. are cultivated in our water-lily houses, *e.g.* *N. Lotus* L. sometimes supposed to be the sacred lotus of Egypt (see Nelumbium). They grow in shallow water. There is a stout rhizome creeping on the earth, with roots on the underside. At the tip it is bent upwards, and bears stipulate leaves and flrs. on long stalks. The peduncle occupies the position of one of the leaves of the spiral, and there is no bract at its base. The leaf is large and floats on the surface of the water; as is usual in such cases it is nearly circular, entire, and leathery, with stomata and cuticle and palisade tissue on the upper side. In very deep water ribbon-like submerged leaves are sometimes formed, and seedlings always produce such leaves at first (see p. 160).

The flr. is ☿, regular, acyclic, and floats on the surface of the water; where it is visited by insects. The outermost floral leaves, 4 in number, exhibit a peculiar aestivation, the anterior being entirely outside, the posterior inside the lateral leaves. According to Caspary (Eichler, *Blüthendiag.* II. 184) the anterior leaf represents the bract ('adnate' to the peduncle; cf. Solanaceae), the two lateral leaves the bracteoles, the posterior a true sepal. Most authors regard the 4 leaves as a calyx, but the morphology is, in either case, very peculiar. The corolla is well developed; there are 4 outer petals alternating with the sepals, and 4 inner alternating with the outer. These 8 form the starting points of as many spirals of petals, usually 4 in each, alternating approximately with the outer 8 and with one another. As we pass inwards the petals become narrower and show transition forms to the sta., which to the number of 50 or 100 continue the flr. inwards. Whilst the calyx is hypogynous the petals and sta. are inserted up the sides of the gynœceum, which is syncarpous, with 10-20 loculi, each containing ∞ ovules scattered over the whole carpellary surface (cf. Butomus). The sessile stigmas form a number of rays upon the upper surface of the gynœceum, as in a poppy. The fruit is a large berry containing numerous seeds, each of which is covered by a spongy aril. Between the aril and the seed are air-bubbles. The fruit ripens under water and when it dehisces the mass of seeds floats up to the surface; there the individual seeds part company, each drifting about until the air escapes (by decay of the aril or otherwise), when it sinks to the bottom of the pond. There is a large perisperm round the endosperm proper.

Nymphaeaceae. Dicotyledons (Archichl. Ranales). 8 genera with about 60 sp. cosmop. Water or marsh plants usually with rhizomes, and with submerged, floating, and aerial leaves (see p. 160 and cf. the genera) and solitary usually large flrs. These show a great variety of pattern. Cabomba is most simple and agrees in type with the other orders of Ranales; whilst in Nuphar, Nymphaea, Victoria, Nelumbium, &c., great modification appears, especially in the gynœceum. In Nelumbium the ovary is still apocarpous, though the cpls. are connected by the curious torus, whilst in the other genera it is syncarpous; in

Nuphar it is superior, in Nymphaea semi-inferior, in Victoria inferior. The perianth too shows much variety, from the simple Cabomba-type to Nuphar, &c. The ovules are usually anatropous. The seed has both endosperm and perisperm (exc. Nelumbium), and is often arillate. For full details of the floral structure see the chief genera, and Eichler's *Blüthendiag.*

Classification and genera (after Caspary):

I. *NELOMBONOIDEAE* (seed exalbuminous; cpls. free in obconical receptacle): Nelumbium (only genus).

II. *CABOMBOIDEAE* (endosperm and perisperm; cpls. free): Cabomba, Brasenia.

III. *NYMPHAEOIDEAE* (do., but cpls. united): Victoria, Euryale, Nymphaea, Nuphar, Barclaya.

[Placed in Ranales by Benth.-Hooker, in Polycarpicae by Warming.]

Nyssa Gronov. ex Linn. Cornaceae. 6 sp. N. Am., Himal., Malaya. *N. multiflora* Wangenb. and others in N. Am. (Tupelo, Pepperidge, Gum-tree) yield timber and edible fruit.

Oberonia Lindl. Orchidaceae (8). 50 sp. trop., exc. Am.

Obione Gaertn. = Atriplex Linn.

Obolaria Linn. Gentianaceae (1, 2). 1 sp. N. Am. Saprophyte (cf. Bartonia) of a purplish green colour with scaly leaves (p. 177).

Ochna Linn. Ochnaceae. 30 sp. trop. As., Afr., Cape Col. The calyx is coloured. Cpls. 3—15, free below, but with a common style. After fertilisation the style falls off and each cpl. gives rise to a drupe, while at the same time the receptacle becomes fleshy underneath them. The leaf is a good one for showing veining.

Ochnaceae. Dicotyledons (Archichl. Parietales). 17 gen. with 210 sp., trop. Most are trees or shrubs with alt. usually simple stip. leaves, and panicles, racemes or cymes (Sauvagesia, &c.) of ☿, usually regular flrs. K 5, free or united at base, imbricate; C 5, rarely 10, contorted; A 5, 10, or ∞, hypogynous or on an elongated axis; $\underline{G}$ (2—5), rarely (10—15), often free below with common style (cf. Apocynaceae). Ovules 1—2—∞ in each cpl., erect or rarely pendulous, always with ventral raphe. The axis swells and becomes fleshy under the fruit, which is usually a cluster of drupes, but sometimes a berry or capsule. Endosperm or not. *Chief genera:* Ochna, Gomphia, Sauvagesia. Benth.-Hooker place Ochnaceae in Geraniales, but unite Sauvagesia and its allies to Violaceae. Warming places O. in Terebinthinae, also placing the Sauvagesieae in Violaceae.

Ochroma Sw. Bombacaceae. 1 sp. trop. Am., W. Ind., *O. Lagopus* Sw. the Bolsa or corkwood. The wood is very light and is used for floats, canoes, &c. The seeds are embedded in hairs.

Ocimum Linn. Labiatae (VII). 45 sp. trop. and warm temp. *O. Basilicum* L. is the basil.

Ocotea Aubl. Lauraceae (1). 200 sp. trop. and subtrop. *O. bullata* E. Mey. (S. Afr.) yields a useful timber.

Odontites (Riv.) Hall. = Bartsia Linn. *O. serotina* Dum. (*O. vulgaris* Moench) = *B. Odontites.*

Odontoglossum H. B. et K. Orchidaceae (28). 100 sp. Mts. of trop. Am. Epiphytes. Many are hot-house favourites.

Odontospermum Neck. (incl. *Asteriscus* Moench). Compositae (IV). 12 sp. Medit. *O.* (*A.*) *pygmaeum* O. Hoffm. is a curious little xerophyte whose fruit-heads close in dry weather (cf. Anastatica, Mesembryanthemum); the seeds only escape in damp weather suitable for germination.

Oenanthe (Tourn.) Linn. Umbelliferae (6). 35 sp. N. Hemisph., S. Afr., Austr. 7 in Brit. (water drop-wort).

Oenothera Linn. (incl. *Godetia* Spach, *Onagra* Tourn., *Xylopleurum* Spach). Onagraceae (IV). 60 sp. Am. *O. biennis* L., the evening primrose, and many others, are favourite garden plants. The flrs. of *O. biennis* emit their scent in the evening and are visited by nocturnal moths, to which they are adapted by their long tubes (p. 91).

Oenotheraceae (Warming) = Onagraceae.

Olacaceae. Dicotyledons (Archichl. Santalales). 25 gen. with 120 sp., trop. Most are shrubs or trees with small ☿ flrs. There is a distinct calyx, resembling the calyculus of Loranthaceae, but probably not equivalent to it. Petals 4—6. Sta. as many or 2 or 3 times as many. Ovary partly sunk in the disc, or free, 2—5-loc. at base, 1-loc. above, with free placenta and 1 ovule hanging down into each loc. (occasionally it is 1-loc. 1-ovuled). Drupe or nut, one-seeded. Seed with testa and endosperm. *Chief genera:* Ximenia, Olax. Benth.-Hooker unite Icacinaceae to O. and place the order in Olacales; Warming places it in Hysterophyta.

Olacales (Benth.-Hooker). The 8th cohort of Polypetalae (p. 133).

Olacineae (Benth.-Hooker) = Olacaceae + Icacinaceae.

Olax Linn. Olacaceae. 30 sp. trop. Old World.

Oldenlandia Linn. (excl. *Hedyotis* Linn.). Rubiaceae (I. 2). 80 sp. trop. Some are heterostyled (dimorphic).

Olea (Tourn.) Linn. Oleaceae (I. 3). 30 sp. Medit., S. Afr., E. Ind., Austr., Polynes. *O. europaea* L. is the olive tree, cultivated in the Medit. region from early ages. The wild form has thorny twigs and a small fruit, the cultivated form (var. *sativa* DC.) is smooth and has a large drupe with oily flesh. The oil is obtained by a process of bruising and pressing the fruit. Olive oil is now largely adulterated with cotton-seed oil, the oils of Arachis, Sesamum, Juglans, &c., imported into Italy for the purpose.

Oleaceae. Dicotyledons (Sympet. Contortae). 21 gen. with 390 sp. trop. and warm temp., esp. E. Ind. They are shrubs and trees usually with opp. leaves, which are exstip., simple or pinnate, often entire. Serial accessory buds occur in the leaf-axils of many sp. (*e.g.* Syringa) in both flowering and vegetative parts. The infl. is racemose or cymose, often bracteolate. Flrs. ☿, rarely unisexual, regular, 2—6-merous, sometimes poly- or a-petalous (Fraxinus, &c.). K typically (4), valvate; C (4) valvate or imbricate, rarely convolute. Sta. 2, epipetalous usually transversely placed, and alt. with cpls. No disc. $\underline{G}$ (2); stigma 2-lobed on simple style; ovary 2-loc. with 2 anatropous ovules in each loc. Fruit a berry, drupe, or capsule, or schizocarp, with 1—4 seeds. Endosperm or none, embryo straight. Olea, Fraxinus, &c., are of economic value.

Classification and chief genera (after Knoblauch):

I. *OLEOIDEAE* (seeds pendulous; fruit not constricted):

1. *Fraxineae* (samara): Fraxinus.
2. *Syringeae* (loculicidal capsule): Forsythia, Syringa.
3. *Oleineae* (drupe or berry): Phillyrea, Olea, Ligustrum.

II. *JASMINOIDEAE* (seeds usually erect; fruit constricted vertically): Jasminum.

[*Jasminoideae* are sometimes classed as a separate family, but their characters are not very constant, and all of them occur occasionally in *Oleoideae*. Benth.-Hooker place O. in Gentianales, Warming in Contortae.]

Oleandra Cav. Polypodiaceae. 6 sp. trop.

Olearia Moench. Compositae (III). 90 sp. Austr., N. Z., Auckland Is. The genus replaces Aster in these regions, and closely resembles it. They are, however, all trees or shrubs.

Olinia Thunb. Oliniaceae. 6 sp. Afr.

Oliniaceae. Dicotyledons (Archichl. Thymelaeales). Only genus Olinia. See *Nat. Pfl.* for details. Placed in Lythraceae by Benth.-Hooker.

Omphalea Linn. Euphorbiaceae (A. II. 7). 10 sp. trop. Am., 1 Madag.

Omphalodes Tourn. ex Moench. Boraginaceae (IV. 1). 24 sp. Eur., As., Mexico. The borders of the achenes are inrolled, so that each fruit is boat-shaped.

Onagra (Tourn.) Adans. = Oenothera Linn.

Onagraceae. Dicotyledons (Archichl. Myrtiflorae). 36 gen. with 470 sp., chiefly N. temp. (see Epilobium). Most are perennial herbs, a few shrubs or trees. Leaves alt., opp., or whorled, simple, rarely stip. Flrs. solitary in the leaf-axils or in spikes, racemes or panicles, ☿, regular or zygomorphic, usually 4-merous (sometimes 2—5). The ovary is inferior and the axis is prolonged beyond it into a tube ('calyx-tube'). K 4, valvate; C 4, usually convolute; A 4+4, or 4, 2, or 1. $\overline{G}$ (4), 4-loc. with axile placentae and ∞ anatropous ovules; the septa are commonly imperfect below; style simple. The flrs. are mostly adapted to bees or Lepidoptera and are often markedly protandrous; those of sp. of Lopezia are explosive. Fruit usually a loculicidal capsule, sometimes a nut or berry. Seeds exalbuminous. Many are cultivated as ornamental flowers.

Classification and chief genera (after Raimann):

A. Fruit an ∞-seeded capsule. Axis not prolonged above ovary. Bracteoles present.

I. *Jussieueae:* Jussieua, Ludwigia.

B. Capsule as above. Axis prolonged. No bracteoles.

II. *Epilobieae* (seed with hairy tuft): Zauschneria, Epilobium.

III. *Hauyeae* (seed with flat wing): Hauya (only genus).

IV. *Onagreae* (seed naked or with membranous edge or with small crown): Clarkia, Oenothera.

C. Nut. 1—4 seeds. Axis prolonged. No bracteoles.

V. *Gaureae:* Gaura.

D. Berry. Axis as in C. No bracteoles.

VI. *Fuchsieae:* Fuchsia (only genus).

E. Capsule. Sta. 1 or 2. No bracteoles.

VII. *Lopezieae:* Lopezia.

F. Nut, hooked. Flr. dimerous.

VIII. *Circaeeae:* Circaea (only genus).

[Benth.-Hooker unite Trapa to O. and place the order in Myrtales; Warming places it in Myrtiflorae.]

Oncidium Sw. Orchidaceae (28). 300 sp. trop. Am. Epiphytes (p. 173). Some sp., *e.g. O. Papilio* Lindl., have flat tubers which make humus-collecting niches against the support; others have fleshy leaves and no tubers.

Onobrychis Linn. Leguminosae (III. 7). 80 sp. temp. Eur., As. Floral mechanism as in Trifolium. *O. sativa* Lam. is the sainfoin, one of the best forage plants for a chalky soil.

Onoclea Linn. Polypodiaceae. 3 sp. N. Hemisph.

Ononis Linn. Leguminosae (III. 4). About 80 sp. Medit., Eur. (3 in Brit.—rest-harrow). Shrubs and herbs, sometimes with thorny lateral branches. The mechanism of the flrs. is intermediate between that of Lotus and that of Trifolium. At first the upper edges of the keel cohere, and the pollen is squeezed out at the tip as in Lotus; afterwards the keel splits and the anthers emerge as in Trifolium. Cleistogamic flrs. occur in some sp.

Onopordon Linn. Compositae (XI). 20 sp. Eur., N. Afr., W. As. *O. Acanthium* L., the cotton thistle, in Brit. Leaves decurrent. Flr. as in Cnicus.

Onosma Linn. Boraginaceae (IV. 4). 70 sp. Medit., Himal.

Onychium Kaulf. Polypodiaceae. 4 sp. subtrop.

Ophelia D. Don = Swertia Linn.

Ophioglossaceae. Filicineae Eusporangiatae. 3 gen. with 17 sp. trop. and temp. They are all small herbaceous plants, some tropical species being epiphytic; there is a root-stock or rhizome bearing roots in acropetal succession, and giving off leaves which project above the soil. The leaf bases are usually fleshy and fit closely together concealing the stem. The leaf splits into a dorsal and a ventral part, the former being the 'sterile' green blade, the latter the 'fertile' sporangiferous spike, often much branched and containing the sporangia sunk in its tissues. The spores are all of one kind and give rise, as far as known, to subterranean colourless prothalli, living saprophytically. *Genera:* Ophioglossum (sporangia sessile, in two rows, forming a narrow close spike), Botrychium (sporangia in small crested clusters forming a long loose spike), Helminthostachys (sporangia peltate, borne on sporangiophores which arise from the two sides of the fertile spike).

Ophioglossum Linn. Ophioglossaceae. 9 sp. trop. and temp. *O. vulgatum* L., adder's-tongue, is found in Brit. The leaves are developed very slowly, one appearing above the soil each year. Adventitious buds are formed on the roots and thus the plant multiplies vegetatively. The sporangiferous spike is usually unbranched, except in *O. palmatum* L., where "instead of a single spike there are a number arranged in two rows along the sides of the upper part of the petiole and the base of the lamina." (This sp. and *O. pendulum* L. are epiphytic.) The roots most often arise in relation to the leaves, one appearing at the base of each; they are commonly unbranched.

Ophiopogon Ker-Gawl. Liliaceae (VIII). 4 sp. Japan, China. The mucilaginous tubers of *O. japonicus* Ker-Gawl. are edible. [Hæmodoraceae Benth.-Hooker.]

Ophiorrhiza Linn. Rubiaceae (I. 2). 50 sp. trop. As., Indo-mal.

Ophiurus Gaertn. f. Gramineae (II). 4 sp. trop. Included in Rottboellia in *Nat. Pfl.*

Ophrys Linn. Orchidaceae (3). 30 sp. Eur., W. As., N. Afr. (*O. apifera* Huds., bee-orchis, *O. aranifera* Huds., spider-orchis, *O. muscifera* Huds., fly-orchis, in Brit.). Terrestrial herbs with the habit and floral characters of Orchis. *O. apifera* is one of the few self-fertilising orchids. If the pollinia are not removed by insects (as in Orchis) they drop out of the anther and dangle on their long caudicles in front of the stigma, against which they get blown or knocked (see Darwin).

Oplismenus Beauv. Gramineae (V). 5 sp. trop. and subtrop.

Opopanax Koch. Umbelliferae (7). 2 sp. Medit. Gum opopanax is obtained from incisions in the roots. It is used in perfumery.

Opuntia Tourn. ex Mill. Cactaceae (II). 200 sp. Am. Fleshy stemmed plants, usually with small fleshy leaves, which drop off very early (see order). In *O. subulata* Engelm. the leaves are large and do a good deal of assimilation. Some, *e.g. O. Stapeliae* DC., have mammilla-like cushions; *O. brasiliensis* Haw. has the main stem cylindrical and the lateral ones flat; most sp. have all the stems flattened, *e.g. O. vulgaris* Mill. (prickly pear), *O. Ficus-indica* Mill. (Indian fig), &c. (see Goebel's *Pflanzenbiol. Sch.* I. p. 73 seq.). The leaves of the lateral shoots usually form groups of thorns, but in *O. diademata* Lem. are ribbon-like and scaly. Many are vegetatively propagated by the detachment of branches, *e.g. O. fragilis* Haw., which rarely flowers at all. The fruits of prickly pear &c. are edible; some are used for hedge-making, others as food for cochineal-insects (see Nopalea). [For *O. coccinellifera* Steud. see Nopalea.]

Opuntiales. The 20th cohort of Archichlamydeae (p. 130).

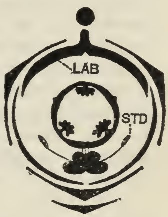
Orchidaceae. Monocotyledons (Microspermae). Over 400 gen. with 5000 sp. cosmop., abundant in trop., rare in arctic regions. They agree in some general features of habit, &c., *e.g.* they are all perennial herbs, but differ widely in detail, owing to the diversity of conditions in which they exist—land-plants, epiphytes, saprophytes, &c. Within the tropics they form an important feature of the vegetation, living chiefly as epiphytes (p. 173). Most of the temperate forms are terrestrial.

The plant as a whole may be built up in one of three ways. It may be (1) a monopodium, the main axis growing steadily on, year after year, and bearing the flrs. on lateral branches; (2) an *acranthous* sympodium, the main axis being composed of annual portions of successive axes, each of which begins with scale leaves and *ends* in an infl.; (3) a *pleuranthous* sympodium, where the infls. are borne on *lateral* axes, the shoot which for the current year continues the main axis, simply stopping short at the end of its growing period, and not ending in an infl. [see p. 43]. These three types of construction are used in the classification of the order (see below).

The saprophytic orchids are but few; they have no green leaves; below the soil, in the humus, is a fleshy rhizome, with (Neottia) or without roots. The rhizome is much branched, and does part or all of the work of absorption. Mycorhiza (p. 39) occurs in most or all. The terrestrial forms are all sympodial, and have usually a rhizome; each annual shoot bends up into the leafy shoot of the current year. Many being xerophytic, and all perennial, it becomes a necessity that there should be a storage reservoir to last over the non-vegetative period of the year. In a great many sp. this reservoir takes the form of a thickened internode of the stem: in many sp. again, among which the Brit. orchids are included, the bud for the next year's growth, *i.e.* the next part of the sympodium, is laid down at the base of the stem, and from it is developed a thick and fleshy adventitious root, forming a large tuber, which lasts over the winter.

Coming lastly to the epiphytic orchids, which occur in great numbers in the tropics, we find a great variety of forms. [See Schimper, *Die epiphytische Vegetation Amerikas*.] They are mostly of sympodial structure, but the few monopodial orchids also belong to this group. The exceedingly light seeds and the xerophytic habit of many orchids fit them to become epiphytes. The roots of the epiphytic forms are of some interest. In the first place, to fasten the plant to its support there are 'clinging' roots, insensitive to gravity, but negatively heliotropic. The niche between the plant and its support and the network formed by the roots act as reservoirs for humus, and into this project 'absorbing' roots, branches from the others; these are usually, Schimper asserts, negatively geotropic. Finally there are the true aerial roots which hang down in long festoons. The outer layers of cells (the epidermis and *velamen*) are dead and perforated, and act as a sponge to absorb water trickling down over them. Their internal tissue is green (as may be seen on wetting a root) and assimilates. During the dry season a great proportion of the orchids drop their leaves (though they may flower), and 'hibernate' in the condition of fleshy *pseudobulbs*. One pseudobulb, which is a thickened stem-internode, is usually formed each year. In this, water and other reserves are stored. Those epiphytic orchids which do not form these tubers have fleshy leaves which serve the same end. It may be noted that the fleshy leaved orchids, *e.g.* Vanilla, have usually a very feebly developed velamen. Lastly in this connection may be mentioned some of the monopodial forms which have no green leaves at all, assimilating either by the surface of the stem, or by the long dangling aerial roots (Polyrrhiza, &c.).

The infls. are of racemose construction, very often spikes, which look like racemes, the long inferior ovary resembling a stalk. The flr. is irregular and departs very far from the ordinary Monocotyledon type. There are two chief divisions of O., with different flrs., the *Monandrae* and the *Diandrae*, with 1 and 2 sta. respectively; the great majority are monandrous. Perianth in 2 whorls, epigynous, petaloid. The posterior petal is usually larger than the rest, and is termed the *labellum*; by the twisting (*resupination*) of the ovary through 180° it comes round to the anterior side of the flr. and forms a landing place for insects. In many O. its structure is exceedingly complex in connection with the pollination-mechanism of the flr. The essential organs of the flr. are all comprised in a central structure by which the O. can be recognised at a glance, viz. the *column*, which consists in the simpler cases of the combined style and sta. (to use the old-fashioned expression; in reality it is very probably an outgrowth of the axis, bearing the anthers and stigmas at the top). In the monandrous forms the column exhibits one anther and two fertile stigmas (often ± confluent), together with a special organ, the *rostellum*, which represents the third stigma. The single anther is the anterior one of the outer whorl (if we imagine the flr. of O. derived from a typical 3-merous flr.); the other two of this whorl are entirely absent, and also all those of the inner whorl, though in some genera, *e.g.* Orchis, the anterior two are represented by staminodes upon the sides of the column. The two fertile stigmas are the posterior pair, and the third (anterior) is represented by the rostellum (in using the



Floral diagram of Orchis, before resupination (after Eichler, modified); LAB = labellum, STD = staminode.

terms anterior and posterior, the resupination is supposed not to have occurred).

The various organs face the labellum, and, if the flr. of a simple O., *e.g.* Orchis, be examined, they can easily be made out. A little above the base may be seen the two stigmas, then above these a projecting point, the rostellum, and above this again, and behind it, forming the apex of the column, is the anther, which shows two lobes. Each of these is occupied by a *pollinium*, or mass of pollen. Under the microscope the grains of pollen are seen to be tied together in packets by elastic threads; the threads unite at the base of the pollinium and form a cord, the *caudicle*, which runs down into, and is attached to part of the rostellum.

The simple construction found in Orchis &c., as thus described, is replaced by much more complex arrangements in many sp. The labellum itself may be rendered very complex, by the addition of spurs and other outgrowths; very often outgrowths of the summit of the receptacle take place, displacing some of the organs, thus for example in Drymoda and others, the labellum and the sepals on either side of it are carried forward on an axial protuberance in such a way that the sepals appear to spring from the labellum, the axial growth (*chin*) appearing like the basal part of this organ. Some of these constructions are very complex. Several are described in connection with the genera to which they belong, but for details reference must be made to *Nat. Pfl.*

Similarly the column shows great variety in structure, for details of which refer as above. One point may be mentioned specially as of importance in classification. In the simple case of Orchis &c., described above, the *base* of the anther loculi is against the rostellum; such cases are called *basitonic;* in others it is the apex that is next the rostellum (Oncidium, &c.), and these are *acrotonic.*

[Diandrae. So far only monandrous forms have been considered. In Cypripedium and its allies the column has 2 anthers, no rostellum, and a simple stigma, composed of the 3 carpellary stigmas. The two sta. belong to the inner whorl, and the sta. which in Monandrae is fertile, is here represented by a large staminode. The stigma is not sticky, but the pollen is, and it is not combined into pollinia.]

The ovary is inferior in all O., unilocular with 3 parietal placentae (exc. Apostasia), and very numerous ovules, which do not develope until fertilisation of the flr. occurs.

The adaptations of orchid flowers to *fertilisation* by insects are endless, and many very complicated. Reference must be made to textbooks for the details. No student should omit to read Darwin's *Fertilisation of Orchids*, at least the first two and the last chapters. In it will be found accounts of the mechanism of most of the common genera. A few general points only can be mentioned here; in the description of the individual genera other more detailed features are treated. Very few of the order secrete free honey; in most cases the insect has to bite into or drill the tissue for the juice therein contained; this tissue is usually part of the labellum—often a spur at the base—or the basal part of the column. The pollinia are removed as a rule when the insect is going out of the flr. In most cases the insect in entering displaces the rostellum or some portion of it, and thereby exposes and comes into contact with a sticky mass (due to disorganisation of cells formerly living). This becomes cemented to the insect while it is drilling for honey, and as the insect goes out again it takes with it the viscid lump, together with the pollinia, either merely glued to it, or attached by caudicles. In many cases the pollinia are in such a position that when the insect enters the next flr. they will touch the stigmas. In others this is not so, *e.g.* Orchis, where the anthers and stigma are far apart on the column, and in such cases the pollinia, on getting out of the anther, execute a hygroscopic movement which brings them into the proper position on the insect's body to strike the stigmas. Such is the general principle of the orchid mechanism, but the variety in detail is endless. Many flrs. have the most extraordinary devices, *e.g.* Coryanthes, Stanhopea, Vanda, &c. See under individual genera.

The *fruit* is a capsule, containing usually a gigantic number of exceedingly small and light seeds, which are well suited to wind distribution (hence, among other causes, the epiphytic habit of so many of the order). It may be noted that, as Darwin has pointed out, this production of immense numbers of seeds is an evidence of lowness of organisation, and contradicts the impression that would otherwise be derived from the floral complications.

The O. are favourites in horticulture, but Vanilla is the only one of economic importance.

Classification and chief genera (after Pfitzer):—

A. DIANDRAE (two stamens).

1. Apostasiinae: Apostasia.
2. Cypripedilinae: Cypripedium.

B. MONANDRAE (one stamen).

a. *BASITONAE* (basitonic, anther not falling off):

3. Ophrydinae: Ophrys, Orchis, Habenaria, Disa.

b. *ACROTONAE* (acrotonic, anther usually falling easily):

α. ACRANTHAE (acranthous sympodial):

I. Convolutae (leaves convolute in bud, with no distinction between blade and sheath):

4. Neottiinae: Vanilla, Epipactis, Neottia.

II. Articulatae (as I., but with a joint between blade and sheath):

5. Thuniinae: Thunia, Trichosma.
6. Coelogyninae: Coelogyne, Pholidota.

7. Collabiinae: Collabium.
III. **Duplicatae** (leaves folded in bud):
8. Liparidinae: Liparis, Corallorhiza.
9. Polystachyinae: Galeandra.
10. Podochilinae: Podochilus.
11. Glomerinae: Ceratostylis.
12. Pleurothallidinae: Masdevallia, Pleurothallis.
13. Laeliinae: Epidendrum, Cattleya, Laelia.
14. Sobraliinae: Sobralia.
β. PLEURANTHAE (pleuranthous sympodial):
I. **Convolutae** (leaves convolute in bud):
15. Phajinae: Phajus, Calanthe.
16. Cyrtopodiinae: Lissochilus.
17. Catasetinae: Mormodes, Catasetum.
18. Lycastinae: Lycaste.
19. Gongorinae: Coryanthes, Stanhopea, Gongora.
20. Zygopetalinae: Zygopetalum.
II. **Duplicatae** (leaves folded in bud):
1. *Sympodiales* (sympodial).
21. Dendrobiinae: Dendrobium, Eria.
22. Bolbophyllinae: Drymoda, Bolbophyllum.
23. Thelasinae: Thelasis.
24. Cymbidiinae: Cymbidium.
25. Thecostelinae: Thecostele.
26. Steniinae: Stenia.
27. Maxillariinae: Maxillaria, Scuticaria.
28. Oncidiinae: Ada, Odontoglossum, Oncidium.
29. Huntleyinae: Pescatorea.
2. *Monopodiales* (monopodial).
30. Dichaeinae: Dichaea.
31. Sarcanthinae: Phalaenopsis, Vanda, Angraecum, Polyrrhiza, Aerides.

[Placed in Microspermae by Benth-Hooker, in Gynandrae by Warming].

Orchideae (Benth.-Hooker) = Orchidaceae.

Orchis (Tourn.) Linn. (incl. *Anacamptis* Rich., *Himantoglossum* Spreng.). Orchidaceae (3). 70 sp. Eur., temp. As., N. Afr., Am. (10 sp. in Britain, of which the most familiar are *O. mascula* L., the early purple orchis, and *O. maculata* L., the spotted orchis). They are sympodial perennials forming one tuber each year (see Orchidaceae for description). The flrs. stand in a dense spike and have an ingenious mechanism for insect fertilisation. The anther is basitonic and well above the stigmas. The rostellum has an outer firm pouch, inside which is the viscid substance to which are firmly attached the caudicles of the pollinia. An insect entering the flr. probes the spur of the labellum and its back comes into contact with the rostellum and depresses the pouch. This causes the viscid substance to adhere to the insect. The tissue of the spur has to be drilled for honey, and while this is being done the cement rapidly sets, so that, as the insect leaves the flr., it takes with it the pollinia, standing upright on their caudicles. If they remained in this position they would evidently never touch the stigmas of another flr., but as soon as the caudicles are exposed to air, they contract on the side towards the base of the flr. (i.e. towards the insect's head) and move the pollinia downwards from ! to ⁃. In this position, when the insect enters another flr., they pass under the rostellum and strike the stigmas. [See Darwin's *Orchids* for details of the different sp.]

Oreodoxa Willd. Palmae (IV. 6). 6 sp. trop. Am. Monœcious; flrs. in groups of 3, a ♀ between two ♂. *O. oleracea* Mart. is the cabbage palm; the young head of leaves is cut out and eaten. The fruit yields an oil, and a form of sago is obtained from the stem (see Metroxylon). *O. regia* H. B. et K. is the royal palm or Palmiste.

Oreopanax Dcne. et Planch. Araliaceae. 40 sp. trop. Am.

Origanum Tourn. ex Linn. Labiatae (VI. 11). 30 sp. Eur., As., Medit. *O. vulgare* L. (marjoram) in Brit., used as a flavouring herb. *O. Majorana* L. yields oil of marjoram by distillation.

Orlaya Hoffm. = Daucus Tourn.

Ornithidium Salisb. Orchidaceae (27). 20 sp. trop. Am.

Ornithocephalus Hook. Orchidaceae (28). 20 sp. trop. Am.

Ornithogalum (Tourn.) Linn. Liliaceae (V). 70 sp. temp. Old World. *O. umbellatum* L. (star-of-Bethlehem) in Brit.

Ornithopus Linn. Leguminosae (III. 7). 8 sp. Medit., W. As., trop. Afr., S. Brazil. *O. perpusillus* L. in Brit. (bird's foot). *O. sativus* Brot. (Seradella, Serratella) affords good fodder.

Ornus Neck. = Fraxinus Tourn.

Orobanchaceae. Dicotyledons (Sympet. Tubiflorae). 12 gen. with 125 sp. chiefly N. temp. Old World; a few Am. and trop. All are parasitic herbs with little or no chlorophyll, attached by suckers formed upon their roots to the roots of other plants (the seeds of Orobanche only germinate when in contact with a root of a host). For details see genera and cf. p. 176. Infl. terminal, a raceme or spike (exc. Phelipaea, which has a solitary terminal flr.). Flr. ☿, zygomorphic. Calyx hypogynous, gamosepalous, with 2—5 teeth. Corolla (5), imbricate, 2-lipped. Sta. 4, didynamous, epipetalous; anthers opening longitudinally. $\underline{G}$ usually (2), rarely (3), 1-loc. Placentae parietal, often T-shaped in section or branched. Ovules ∞, anatropous. Style 1. Loculicidal capsule. Seeds small, with minute undifferentiated embryo in oily endosperm. *Chief genera:* Orobanche, Christisonia, Lathraea, Phelipaea. Placed in Personales by Benth.-Hooker; Warming unites O. to Gesneraceae, with which they have much in common.

Orobanche (Tourn.) Linn. Orobanchaceae. 90 sp. temp. and subtrop.;

7 in Brit. (broom-rape). They are parasitic by their roots upon the roots of other plants, and have no green tissue of their own (p. 176). *O. ramosa* L. is common on hemp. *O. major* L. (*O. elatior* Sutton) on Centaurea &c. (in Brit.), *O. minor* Sutton on Clover. Some are confined to one host, *e.g.* *O. Hederae* Duby to ivy, others are more general in their attacks.

Orobus (Tourn.) Linn. = Lathyrus Tourn. *O. hirsutus* L. = *L. hirsutus*, *O. niger* L. = *L. niger*, *O. pratensis* Stokes = *L. pratensis*; *O. sylvaticus* Baumg. (*O. vernus* L.) = *L. vernus*; *O. tuberosus* L. = *L. montanus*.

Orontium Linn. Araceae (III). 1 sp. Atlantic N. Am.

Oryza Linn. Gramineae (VI). 6 sp. trop., the most important of which is *O. sativa* L., the rice plant, the chief food plant of the world. It is an annual about 1—6 feet high. The common rice is cultivated in hot steamy lowlands, and the fields are covered with water; the mountain form is cultivated up to 6000 feet without irrigation. The grain in the husk is known as paddy.

Osbeckia Linn. Melastomaceae (I). 50 sp. Old World trop.

Osmanthus Lour. Oleaceae (I. 3). 10 sp. E. and S. As., Polynes., N. Am. *O. fragrans* Lour. (*Olea fragrans* Thunb.) is often cultivated in hot-houses; it has an edible fruit, and its leaves are used to perfume tea.

Osmunda Linn. Osmundaceae. 6 sp. temp. and trop. *O. regalis* L., the royal fern, is found in Brit. It has a root-stock bearing scale leaves below the soil and ordinary leaves above. The stock may sometimes be found a foot high, like the stem of a tree fern. The fronds are large (1—10 feet); the lower pinnae are vegetative, the upper are reproductive only and form a sort of panicle. They are densely covered with sori, which have no indusium and have a peculiar annulus consisting of a round group of cells at one side of the apex. The sporangium dehisces longitudinally. Other sp. have the fertile pinnae on the lower part of the leaf, others again have separate vegetative and reproductive leaves.

Osmundaceae. Filicineae Leptosporangiatae (Homosporous). 2 gen. with 10 sp. trop. and temp. Short-stemmed ferns, with naked sori. The sporangia are shortly stalked and have an annulus, consisting of a roundish group of cells at one side of the apex; they open by a longitudinal fissure. *Genera:* Osmunda (sori on special pinnae), Todea (sori on backs of ordinary pinnae).

Osteomeles Lindl. Rosaceae (II. 4). 10 sp. Andes, Sandwich Is., &c.

Osteospermum Linn. Compositae (IX). 38 sp. S. Afr.

Ostrowskia Regel. Campanulaceae (I. 1). 1 sp. Turkestan.

Ostrya Mich. ex Linn. Betulaceae. 2 sp. N. temp. Like Carpinus. *O. virginica* Willd. (lever-wood) furnishes a hard wood.

Othonna Linn. Compositae (VIII). 80 sp. S. Afr. Xerophytes (p. 16.) with swollen roots and often fleshy leaves.

Ouratea Aubl. = Gomphia Schreb.

Ourisia Comm. ex Juss. Scrophulariaceae (III. 10). 19 sp. S. temp.
Ourouparia Aubl. = Uncaria Schreb.
Ouvirandra Thou. = Aponogeton Thunb.
Oxalidaceae. Dicotyledons (Archichl. Geraniales). 7 gen. with 250 sp. mostly trop. and subtrop. Most are perennial herbs with alt. often compound exstip. leaves and large flrs., usually in cymes. Flr. ☿, regular. K 5, imbricate, persistent; C 5, twisted or imbricate, free or slightly united; A 10, obdiplostemonous (i.e. the outer whorl opp. to the petals, the inner to the sepals, and thus the cpls. opp. to the petals, instead of to the sepals, as in diplostemonous flrs. with two whorls of sta. in proper alternation), united below, with introrse anthers; $\underline{G}$ (5), with free styles, 5-loc., with axile placentae; ovules in 1 or 2 rows in each loc., or few, anatropous, with micropyle facing upwards and outwards. Fruit a capsule or berry; embryo straight, in fleshy endosperm. *Chief genera:* Oxalis, Biophytum, Averrhoa. The order is closely allied to Geraniaceae, to which it is united by Benth.-Hooker. The chief difference is in the fruit. Warming places it in Gruinales.
Oxalis Linn. Oxalidaceae. 220 sp. cosmop. chiefly S. Afr., Am. *O. Acetosella* L. (wood-sorrel) in Brit. It is a small herb with monopodial rhizome and ternate leaves, which sleep at night and in cold weather, the leaflets bending downwards. The flr. is protandrous; the stalk bends downwards and the flr. closes in dull or cold weather. Cleistogamic flrs. (cf. Viola, and see p. 98) occur, sometimes, it is said, below ground. The fruit is a loculicidal capsule. The seed has a fleshy aril springing from the base. When ripe the cells of the inner layers are extremely turgid, and a small disturbance causes the aril to turn inside out, as one might turn a glove-finger, from ∪ to ∩. This is done instantaneously and the seed is shot off to some distance.

Many sp. have bulbous or tuberous stems. Some, *e.g. O. bupleurifolia* A. St. Hil. have phyllodes in place of the ordinary leaves (cf. Acacia). The flrs. are solitary or in cymose infls. Many sp. exhibit trimorphic heterostyled flrs. (see Darwin *Forms of Flrs.*); there are three stocks of plants, one bearing flrs. with long styles, and mid- and short-length sta., the others with mid or short styles and correspondingly long and short or long and mid sta. (cf. Lythrum). Some sp. produce axillary bulbils: others reproduce vegetatively by underground offshoots. [See Hildebrand's *Lebensverhältnisse d. O.-arten*, Jena, 1884.] The tubers of *O. Deppei* Lodd. (S. Am., Mex.), and others, are used as food.
Oxera Labill. Verbenaceae (IV). 12 sp. New Caled.
Oxybaphus L'Hérit. Nyctaginaceae. 12 sp. W. Am., Himal. United to Mirabilis in *Nat. Pfl.*
Oxycoccus Tourn. ex Adans. = Vaccinium Linn. *O. palustris* Pers. = *V. Oxycoccus.*

Oxygraphis Bunge. Ranunculaceae (3). 9 sp. N. temp.

Oxylobium Andr. (*Callistachys* Vent.). Leguminosae (III. 2). 27 sp. Austr.

Oxymitra Hook. f. et Thoms. Anonaceae (4). 50 sp. Old World trop.

Oxypetalum R. Br. Asclepiadaceae (II. 2). 80 sp. Brazil, Mexico, W. Indies.

Oxyria Hill. Polygonaceae (I. 2). *O. digyna* Hill, the only sp., in N. Arctic and subarctic regions (in Brit. an alpine plant). Like Rumex, but dimerous, and with 'dédoublement' of the outer sta.

Oxytropis DC. Leguminosae (III. 6). 150 sp. N. temp.; 2 in Brit.

Pachira Aubl. Bombacaceae. 4 sp. trop. Am. United to Bombax in *Nat. Pfl.*

Pachyrhizus Rich. Leguminosae (III. 10). 2 sp. trop. Am., As., largely cultivated for the edible tuberous root (Yam-bean).

Pachysandra Michx. Buxaceae. 2 sp. Japan, Alleghanies (cf. Epigaea).

Padus Linn. = Prunus Tourn.

Paederota Linn. Scrophulariaceae (III. 10). 2 sp. Mts. of Eur. (p. 149).

Paeonia (Tourn.) Linn. Ranunculaceae (1). 15 sp. Eur., As., west N. Am. *P. officinalis* L. is the common Paeony, noteworthy for its tuberous roots, large flrs. with great secretion of honey, slight cohesion of cpls., and follicle with red seeds. The protogynous flrs. close at night.

Paepalanthus Mart. Eriocaulaceae. 215 sp. S. Am., 1 N. Am., 1 S. Afr.

Palafoxia Lag. Compositae (VI). 7 sp. U.S.

Palaquium Blanco (*Dichopsis* Thw.). Sapotaceae (I). 50 sp. Indo-mal. *P. Gutta* Burck was formerly the chief source of gutta-percha, but it is now quite extinct except in cultivation, and the commercial article is obtained from other sp. and from *Payena Leerii*, &c. The trees are cut down or ringed and the milky latex coagulates, forming gutta percha (cf. caoutchouc).

Palava Juss. (*Palaua* Cav.). Malvaceae (I). 3 sp. Chili, Peru.

Palicourea Aubl. Rubiaceae (II. 15). 100 sp. trop. Am.

Palisota Rchb. Commelinaceae. 8 sp. trop. W. Afr.

Paliurus Tourn. ex Mill. Rhamnaceae. 2 sp., one, *P. aculeatus* Lam. (Christ's thorn, cf. Zizyphus), S. Eur. to China, the other, *P. ramosissimus* Poir. in China and Japan. The former has stipular thorns, one straight, the other recurved; the latter has both thorns straight. The fruit has a horizontal wing, developed at the base of the style after fertilisation.

Palmae. Monocotyledons (Principes). 128 gen. with 1100 sp. trop. and subtrop.; most of the genera are well localised in the various floral regions, the chief exceptions being *Cocos nucifera*, *Elaeis guineensis* and *Raphia vinifera*. The palms form a characteristic feature of the vegetation of the tropics (pp. 155, 190). The vegetative habit is familiar—a crown of leaves at the end of an unbranched stem (Hyphaene is branched). The stem exhibits various forms; some palms, *e.g.* Nipa, Phytelephas, have a short stock bearing 'radical' leaves; some, *e.g.* Geonoma, Calamus, Desmoncus, have a thin reed-like stem with long internodes (the two latter genera are climbers); others again have a tall stem with a crown of leaves at the top. The stem is often covered with the remains of old leaf-sheaths, or is thorny. Its height reaches 150 feet in some sp., and it grows slowly in thickness, by a method which requires investigation. At the base the stem is usually conically thickened or else provided with buttress roots; this gives the necessary mechanical rigidity and is a consequence of the fact that the stem does not curve in a gale but bends from the base, from a position like | to one like /. The stems of Cocos and other palms are curved instead of straight; the meaning of this is unknown.

The leaf is very characteristic; the only closely similar leaf is that of Carludovica, though those of Cycads and some tree ferns have a superficial likeness to palm-leaves. Some genera have palmate (fan) leaves, some pinnate (feather) leaves, but this structure arises by a development unlike that which gives rise to these forms in Dicotyledons and more like that which occurs in Araceae (see *Nat. Pfl.*). The leaf is usually very large, and at the base of the petiole is a sheath, which makes a firmer attachment to the stem than a mere articulation. The sheath contains many bundles of fibres, which remain after the decay of the softer tissues. The pinnae are folded where they meet the main stalk of the leaf, sometimes upwards (*induplicate*, V in section), sometimes downwards (*reduplicate*, Λ in section); these characters are important in classification. The leaf emerges from the bud in an almost vertical line and thus, placing its apex to the sky, escapes excessive radiation and transpiration. The palms are pronounced sun-plants (p. 142), and show xerophytic characters in their leaves. The leaf-surface is glossy with a thick cuticle, and is rarely arranged perpendicularly to the incident rays. Often the leaf is corrugated, or placed at an angle by the twisting of the stalk or by the upward slope of the stalk; sometimes the leaflets slope upwards, and so on.

The infl. is usually very large and much branched. In Corypha and others it is terminal, its production being a mark of the end of the life of the plant (cf. Agave), but usually it is axillary; sometimes the infls. are in the axils of the current leaves, sometimes lower on the stem. The branching is racemose and the flrs. are often embedded in the axis, so that the whole is often termed a spadix. It is enclosed in a spathe of several leaves and emerges from it when the flrs. are ready to open. Some Palms are diœcious, some monœcious, in the latter case often with the flrs. in groups (small dichasia) of 3, one ♀ between two ♂.

The flr. has usually the formula P 3+3, A 3+3, $\underline{G}$ 3 or (3). The perianth has both whorls alike and varies in texture. The cpls. when united may form a 1-loc. or 3-loc. ovary, with 3 or sometimes 1, anatropous ovules (rarely semi-anatropous, or orthotropous). The pollination-methods of the Palms want investigation; some, *e.g.* Cocos, are wind-pollinated, others are doubtless entomophilous.

The fruit is a berry or drupe; in the latter case the endocarp is usually united to the seed. The fruit in *Lepidocaryinae* is covered with dry woody scales. The seed has a large endosperm; in date, vegetable ivory &c. it is very hard, the non-nitrogenous storage-material taking the form of cellulose, which is deposited upon the cell walls. In germination the cotyledon lengthens and pushes out the radicle, and then the plumule grows out of the sheathing cotyledon (see *Nat. Pfl.*).

Economically, the P. are very important, furnishing many of the necessaries of life in the tropics &c. Many have edible fruit or seed, *e.g.* date (Phoenix) and coco-nut (Cocos); the stems contain much starch as reserve food, especially in those sp. which save up for a great terminal infl., *e.g.* Metroxylon (sago), Caryota, &c.; the rush of sap to the infl., especially in the cases just mentioned, is great; and by tapping the stem great quantities of sugar-containing fluid may be obtained and utilised, either directly as a source of sugar or indirectly to make intoxicating drinks by fermentation. The bud of leaves at the top of the stem is often used as cabbage. The stems are used in building, but do not yield plank-timber; the leaves are used in thatching and basket-making, and for hats, mats, &c.; the fibres of the leaf-sheaths are used for ropes &c.; other P. furnish oil (*e.g.* Elaeis, Cocos), wax (Copernicia), vegetable ivory (Phytelephas, &c.), betel-nuts (Areca), &c.

Classification and chief genera (after Drude):

A. Perianth 6-partite, enclosing the fruit after fertilisation.

I. *CORYPHINAE* (spadix loosely branched, often a prolix panicle; flrs. single or in long rows flowering from above; cpls. 3, or loosely united, separating after fertilisation; berry; fan or feather leaves, induplicate):

1. *Phoeniceae:* Phoenix.
2. *Sabaleae:* Chamaerops, Rhapis, Corypha, Livistona, Sabal, Copernicia.

II. *BORASSINAE* (spadix simple or little branched with thick cylindrical twigs; flrs. markedly diclinous dimorphic, invested with bracts, the ♂ in 1—∞ cincinni in grooves of the twigs; cpls. (3), fully united, producing a one-seeded drupe; fan leaves, induplicate):

3. *Borasseae:* Borassus, Lodoicea.

III. *LEPIDOCARYINAE* (spadix branched once or more in a 2-ranked arrangement; flrs. in cincinni or 2-ranked spikes with bracts and bracteoles round them; cpls. (3), fast united, covered with scales; fruit 1-seeded, covered with hard scales; feather or fan leaves, reduplicate):

4. *Mauritieae:* Mauritia.

5. *Metroxyleae:* Raphia, Metroxylon, Calamus.

IV. *CEROXYLINAE* (spadix simple or one or several times branched; flrs. diclinous, usually dimorphic; when diœcious, solitary with rudimentary bracts, when monœcious usually in cymes of 3 flrs., 2 being ♂ and 1 ♀, or rarely ∞ ♂ and 1 at the end of the row being ♀; cpls. (3), 3- 2- 1-loc.; fruit smooth, not scaly; feather leaves):

6. *Arecineae:* Caryota, Arenga, Leopoldinia, Iriartea, Ceroxylon, Chamaedorea, Oreodoxa, Euterpe, Areca.

7. *Cocoineae:* Elaeis, Attalea, Cocos, Bactris, Desmoncus.

B. Perianth rudimentary in ♂ or ♀. Fruits in dense heads.

V. *PHYTELEPHANTINAE:* Phytelephas, Nipa (only genera).

[Placed in Calycinae by Benth.-Hooker, in Spadiciflorae by Warming.]

For further details of P. see *Nat. Pfl.*, Haberlandt's *Tropenreise*, pp. 62 seq., Seemann's *History of the Palms*, and *Treas. of Bot.*

Panax Linn. (incl. *Cheirodendron* Nutt., *Nothopanax* Seem.). Araliaceae. 30 sp. As., Afr., Polynes., Austr., N.Z.

Pancratium Dill. ex Linn. Amaryllidaceae (1). 12 sp. Medit., trop. As.

Pandanaceae. Monocotyledons (Pandanales). 2 gen. with 80 sp., characteristic plants of the Old World tropics (p. 195). They are mostly sea-coast or marsh plants with tall stems supported upon flying-buttress roots, and frequently branched; some are climbers. The aerial roots have marked root-caps of membranous texture. The leaves are in 3-ranked phyllotaxy, but the stem is usually twisted so that the leaves form well-marked spirals (whence the name screw-pine). The leaf is parallel-veined, long and narrow, with an open sheath and usually thorny margin; it is generally sharply bent downwards at the middle, and is corrugated like a palm leaf. The infl. is usually a racemose spadix with neither bracts nor bracteoles, and it is difficult to make out the individual flrs. The ♂ flrs. in sp. of Freycinetia have a rudimentary gynœceum, in the rest of the order they have not. The floral axis bears a number of sta., arranged in a raceme- or umbel-like manner upon it. The gynœcium in the ♀ flr. consists of ∞ cpls. in a ring, 1-loc. in Freycinetia, multi-loc. in Pandanus, the union being more or less complete, or it may be reduced, even to 1 cpl., or to a row of cpls. arranged transversely. Stigmas sessile. Ovules anatropous. Fruit a berry in Freycinetia, a multiloc. drupe in Pandanus. Both genera yield useful products. *Genera:* Freycinetia, Pandanus. Placed in Nudiflorae by Benth.-Hooker, in Spadiciflorae by Warming.

Pandanales. The 1st cohort of Monocotyledons (p. 125).

Pandaneae (Benth.-Hooker) = Pandanaceae.

Pandanus Rumph. ex Linn. f. Pandanaceae. 50 sp. trop. As. and Afr. (the screw-pines). Trees with flying-buttress roots. The flrs. are in large heads, enclosed in spathes. The ♂ consists of ∞ sta., arranged in various ways upon the axis, the ♀ of 1—∞ cpls., free or united. Each gives a drupe containing as many seeds as there were cpls. Seeds albuminous. The pericarp is rich in fibres. The fruits of some sp. are cooked and eaten; the leaves are used for weaving.

Panicum Linn. Gramineae (V). 300 sp. trop. and warm temp. The spikelets are 1- or 2-flowered. *P. miliaceum* L. is the Indian millet, *P. frumentaceum* Roxb. the Samoa millet, both important cereals. *P. maximum* Jacq. (Guinea grass) and others are important fodder plants. Many of these are distributed by the animals feeding upon them, for the joints of the stem will grow after passing through the alimentary canal.

Papaver Tourn. ex Linn. Papaveraceae (II). 40 sp. Eur., As., S. Afr., Austr. *P. Rhoeas* L. and 3 others (poppy) in Brit. The flrs. nod in bud, not by their own weight, but by more rapid growth of one side of the stalk. The ovary is crowned by a sessile rayed stigma, each lobe of which stands over a placenta instead of as usual over a midrib. This is commonly explained by supposing each actual ray of the stigma to be formed of one half of each of two adjacent stigmas. The flr. of most sp. contains no honey, and is homogamous; both cross- and self-pollination usually occur with insect visits. The fruit is a round capsule, opening by pores under the eaves of the roof formed by the dry stigmas, so that the seeds are well protected from rain and can only escape when the capsule is shaken by strong winds or other agencies. *P. somniferum* L. is the opium poppy; the drug is obtained by cutting notches in the half ripened capsules, from which the latex exudes and hardens. The seeds of this and other sp. yield an oil on pressure.

Papaveraceae. Dicotyledons (Archichl. Rhoeadales). 28 gen. with 210 sp., chiefly N. temp. Most are herbs with alt. leaves, and sub-orders I. and II. contain latex. Corydalis and Fumaria are climbers, Bocconia a small shrub. The flrs. are solitary or in racemes, or in dichasia with cincinnal tendency, regular or irregular, ☿, hypogynous (exc. Eschscholtzia). K 2 (united in Eschscholtzia), caducous; C 2 + 2, rolled or crumpled in bud (see Hypecoum); A 4 or ∞ or 2 (see sub-orders); in the last case each sta. branches into 3 parts (see fig.), the centre one bearing an entire anther, the lateral ones each half an anther;

Floral diagram of *Corydalis cava* (after Eichler).

$\underline{G}$ (2—8), 1-loc. with parietal placentae, which in Papaver, &c. project into the loc. Ovules generally ∞, anatropous or slightly campylotropous. Fruit a septicidal capsule, or one opening by pores, or a nut; seeds with oily endosperm, and small embryo. The flrs. are mostly large and conspicuous, but many contain no honey and are visited by pollen-seeking insects; they are often protandrous. Those of suborder III. are irregular, and adapted to bees in a way somewhat like that found in Leguminosae. The order is of little economic value; see Papaver.

Classification and chief genera:

I. *HYPECOIDEAE* (petals without spur; sta. 4; cpls. 2): Hypecoum.

II. *PAPAVEROIDEAE* (as I., but sta. ∞; cpls. 2—∞): Eschscholtzia, Chelidonium, Glaucium, Papaver.

III. *FUMARIOIDEAE* (petals with spur; sta. 2, each branched into 3): Dicentra, Corydalis, Fumaria.

Many authors, *e.g.* Warming, split off III. as a separate order, Fumariaceae. Benth.-Hooker place P. in Parietales; Warming places it in Rhoeadinae.

Papayaceae (Warming) = Caricaceae.

Pappea Eckl. et Zeyh. Sapindaceae (I). 2 sp. trop. and S. Afr. *P. capensis* E. et Z. is the 'Wilde Preume' of S. Afr., with an edible fruit; oil is obtained from the seeds, and the timber is useful.

Papyrus Willd. = Cyperus Mich. *P. antiquorum* Willd. = *C. Papyrus*.

Paracaryum Boiss. Boraginaceae (IV. 1). 35 sp. Medit. Orient.

Paradisia Mazzuc. Liliaceae (III). 1 sp. Mts. of Eur. (p. 149), *P. Liliastrum* Bertol. The flr. is adapted to nocturnal moths.

Paramignya Wight. Rutaceae (X). 6 sp. Indo-mal.

Parietales. The 19th cohort (Engler) of Archichlamydeae (p. 129). The 2nd cohort (Benth.-Hooker) of Polypetalae (p. 132).

Parietaria (Tourn.) Linn. Urticaceae. 7 sp. temp. (*P. officinalis* L., pellitory, in Brit.). The flrs. are mostly ☿ (unlike most of the order), and stand in little cymes in the leaf axils. According to Eichler the first flr. is ♀, the bulk of the cyme ☿, and the last flrs. ♂. The ☿ flrs. are exceedingly protogynous, the style protruding from the bud; the sta. develope later, exploding when ripe like those of the nettle, but by this time the stigma is incapable of fertilisation, and usually the style has dropped off altogether, so that at first glance the flr. looks as if it were male.

Paris (Rupp.) Linn. Liliaceae (VII). 6 sp. temp., Old World. *P. quadrifolia* L. (herb-Paris) in Brit. There is a monopodial rhizome and an aerial stem with a whorl of 4 or more net-veined leaves; the aerial stems are formed, not annually, but at irregular periods. Perianth 4- (or more) merous, as well as the other whorls; in herb-Paris the sepals alternate with the foliage-leaves. The flrs. of this sp. are very protogynous, and their colours and scent attract flies.

Parkia R. Br. Leguminosae (I. 6). 19 sp. trop. The flrs. are in heads, of which either the upper or lower flrs. are male or neuter.

Parnassia (Tourn.) Linn. Saxifragaceae (I). 19 sp. N. temp., chiefly in mountain bogs; 1 in Brit.—*P. palustris* L. (grass of Parnassus). The floral axis is hollowed out and united to the base of the ovary. K 5; C 5; A 5, and alternating with them 5 staminodes; $\underline{G}$ (4) or half-inferior, 1-loc., with large projecting parietal placentae. The flr. is protandrous, the anthers in turn dehiscing just above the pistil and then moving outwards. The staminodes are opposite to the petals. Each has a solid nectar-secreting base, and ends above in a candelabra-like structure, each twig of which is terminated by a yellow knob, glistening in the sun and looking like a drop of honey. Flies are deceived by this appearance, and have been seen licking the knobs. [See Eichler's *Blüthendiag.*]

Parochetus Buch.-Ham. Leguminosae (III. 4). 1 sp. Mts. of trop. As. and Afr. It has cleistogamic and open flrs.

Paronychia (Tourn.) Linn. Caryophyllaceae (II. 4). 40 sp. temp. and sub-trop. The small axillary flrs. are concealed by the stipules. In *P. Kapela* A. Kern. the head of fruits breaks off as a whole and is rolled about by the wind.

Paronychiaceae. See Caryophyllaceae (II. 4).

Parrotia C. A. Mey. Hamamelidaceae. 1 sp. Persia, *P. persica* C. A. Mey. Flrs. ☿, apetalous.

Parsonsia R. Br. Apocynaceae (II. 5). 10 sp. Malaya, Austr., Polynes., N.Z.

Parthenium Linn. Compositae (V). 9 sp. N. Am., W. Ind.

Pasania Oerst. = Quercus Tourn.

Paspalum Linn. Gramineae (V). 160 sp. trop., also in temp. Am., where they form a large proportion of the pasture of the Campos, Pampas, &c. Good fodder grasses.

Passerina Linn. Thymelaeaceae. 4 sp. Cape Colony.

Passiflora Linn. (excl. *Tacsonia* Juss.). Passifloraceae. 250 sp. chiefly Am.; a few in As. and Austr., 1 in Madag. They are climbing plants with axillary tendrils. Some sp. have curious bilobed leaves (crescentic or swallow-tailed in shape), the centre lobe not developing. At the base of the leaf-stalk there are usually extra-floral nectaries. The flrs. spring from the same leaf-axils as the tendrils, solitary or in small cymes; the bract is usually 'adnate' to the peduncle. The receptacle is hollowed into a cup, bearing on its margin 5 sepals, 5 petals, and a number of effigurations of the axis—thread-like petaloid bodies, forming a dense mass (the corona) round the central androphore, at whose apex is borne the ovary. Five sta. spring from the androphore at the base of the ovary, and are bent downwards at first; afterwards the styles bend down also. Honey is secreted at the base of the androphore. The fruit is a berry; the seed is enveloped in a fleshy aril. Many passion-flowers are cultivated as ornamental plants. Several have edible fruit, *e.g. P. quadrangularis* L., the Granadilla (trop. Am.), *P. maliformis* L., the sweet calabash (W. Ind.), *P. laurifolia* L., the water-lemon, &c.

Passifloraceae. Dicotyledons (Archichl. Parietales). 18 gen. with 280 sp. trop. and warm temp. Shrubs and herbs, mostly climbers with axillary tendrils, and with alt. stip. leaves. Flrs. ☿ or unisexual, regular. Receptacle of various shapes, often hollowed and frequently with a central andro- or gyno-phore; it is usually terminated by outgrowths, often of petaloid or staminodial appearance, forming the *corona*. K 3—5; C 3—5 or 0; A 3—5; $\underline{G}$ (3), 1-loc. with parietal placentae and several or ∞ anatropous ovules; style 1, simple or branched, or 3—5 separate styles. Capsule or berry. Seed with fleshy aril and endosperm. *Chief genera:* Modecca, Passiflora. Benth.-Hooker include Caricaceae and Malesherbiaceae in P. and place the order in Passiflorales; Warming excludes Caricaceae and places P. in Passiflorinae.

Passiflorales (Benth.-Hooker). The 13th cohort of Polypetalae (p. 134).

Passiflorinae (Warming). The 21st cohort of Choripetalae (p. 137).

Pastinaca Linn. = Peucedanum Tourn. *P. sativa* L. = *Peuced. sativum.*

Patagonium Schrank = Adesmia DC.

Patrinia Juss. Valerianaceae. 13 sp. E. As.

Paullinia Linn. Sapindaceae (I). 120 sp. trop. and sub-trop. Am., 1 in Madag. and Afr. Lianes with watch-spring tendrils (p. 172). Fruit a capsule, often winged.

Paulowilhelmia Hochst. Acanthaceae (IV. A.). 5 sp. trop. Afr. Seeds often with toothed scales, spreading when wetted.

Paulownia Sieb. et Zucc. Scrophulariaceae (II. 6). 2 sp. Chi., Jap. Trees (rare in S.). *P. imperialis* S. et Z. is often cult. in parks.

Pavetta Linn. Rubiaceae (II. 14). 70 sp. palaeotrop. The leaves of many sp. have little warts inhabited by bacterial colonies (Zimmermann in *Prings. Jahrb.* 37, 1901, p. 1).

Pavia Boerh. = Aesculus Linn.

Pavonia Cav. Malvaceae (III). 70 sp. trop. and sub-trop. There are 5 cpls. and 10 styles, 5 of these corresponding to cpls. which abort in development. The cpls. are hooked in fruit.

Pavonia Ruiz et Pav. = Laurelia Juss.

Payena A. DC. Sapotaceae (I). 16 sp. Malaya. *P. Leerii* Kurz yields a good gutta percha (see Palaquium), known as Gutta Sundek.

Pectis Linn. Compositae (VI). 50 sp. Arizona to Brazil.

Pedaliaceae. Dicotyledons (Sympet. Tubiflorae). 14 gen. with 45 sp. trop. and S. Afr., Madag., Indo-mal., mostly shore and desert plants. Herbs or rarely shrubs with opp. leaves and glandular hairs. Flrs. solitary or in cymes (usually 3-flowered), with glands (metamorphosed flrs.) at the base of the stalks, ☿, zygomorphic. K (5); C (5); A 4, didynamous, with a posterior staminode; $\underline{G}$ (2) [$\overline{G}$ in Trapella], with long style and 2 stigmas, 2—4-loc. or apparently 1-loc., often with false septa; ovules 1—∞ per loc., on axile placentae. Capsule or nut, often with hooks. Embryo straight; endosperm thin. Sesame is economically important. *Chief genera:* Pedalium, Sesamum, Harpagophytum. Benth.-Hooker and Warming unite Martyniaceae to P., placing it in Personales and Personatae respectively. The chief distinctions from M. lie in the placentation, the fruit, calyx, and glandular hairs.

Pedalineae (Benth.-Hooker) = Pedaliaceae.

Pedalium Royen ex Linn. Pedaliaceae. 1 sp. trop. Afr. and As.

Pedicellaria Schrank = Gynandropsis DC.

Pedicularis (Tourn.) Linn. Scrophulariaceae (III. 12). 250 sp. N. Hemisph. and S. Am., especially on Mts.; 2 in Brit., *P. palustris* L. and *P. sylvatica* L. (louse-wort), in marshes and moist places. Semi-parasites with loose-pollen flrs., fertilised by humble-bees &c. In a few places in the Arctic regions, P. extends beyond the limit of humble-bees (Bombus) and the flr. has a shorter tube, adapting it to flies.

Pedilanthus Neck. Euphorbiaceae (A. II. 8). 15 sp. trop. Am.

Peganum Linn. Zygophyllaceae. 4 sp. Medit., As., N. Am. The seeds of *P. Harmala* L. yield turkey-red. [Rutaceae, B. & H.]

Peireskia Steud. = Pereskia Plum.

Pelargonium L'Hérit. Geraniaceae. 175 sp., chiefly S. Afr., a few Medit., Austr. Many varieties are cultivated as ornamental plants, of which one is the so-called Geranium of greenhouses, &c. In many sp. the base of the stem is tuberous. An oil, used as a substitute for attar of roses, is distilled in Algeria from *P. odoratissimum* Ait.

Pellaea Link. Polypodiaceae. 45 sp. trop. and subtrop.

Pellionia Gaudich. Urticaceae. 15 sp. trop. As., Polynes. Like Urtica. *P. umbellata* Wedd. has the bracts of the ♂ flrs. united to form an involucre.

Penaea Linn. Penaeaceae. 10 sp. Cape Colony.

Penaeaceae. Dicotyledons (Archichl. Thymelaeales). 5 gen. with 22 sp. S.W. Cape Col. Shrubby xerophytes of ericoid habit, with opposite evergreen leaves. Flowers axillary, solitary or in pairs, the bracts often coloured. Flr. ☿, regular, 4-merous. Receptacle hollow, tubular. No petals. Ovary 4-loc.; style simple. Ovules 2 in each loc., anatropous. Capsule. No endosperm. *Chief genera:* Penaea, Sarcocolla. Placed in Daphnales by Benth.-Hooker.

Pennisetum Rich. Gramineae (V). 40 sp. trop. and subtrop Afr., S. Eur., As., Am. Involucre as in Cenchrus. *P. typhoideum* Rich., the pearl millet, is an important cereal in India.

Pentadesma Sabine. Guttiferae (VI). 1 sp., *P. butyracea* Sabine, the tallow or butter tree, in Sierra Leone. The fruit yields a greasy juice used as butter.

Pentapterygium Klotzsch. Ericaceae (III. 8). 5 sp. E. Himal. to Khasia. Fruit a five-winged berry.

Pentas Benth. Rubiaceae (I. 2). 10 sp. trop. and subtrop. Afr., Madag.

Pentstemon Mitch. Scrophulariaceae (II. 6). 80 sp. N. Am., E. As. Several sp. are cultivated. The posterior sta. is represented by a large staminode which is bent down and lies upon the lower side of the corolla, out of the way of insect-visitors (cf. Scrophularia).

Peperomia Ruiz et Pav. Piperaceae. 400 spec. trop., esp. Am. Many are epiphytes with creeping stems, adventitious roots and fleshy leaves (water-tissue under the upper epidermis, see pp. 167, 175). Flrs. ☿, with 2 sta., arranged in terminal spikes, which may, as in Piper, give rise to a sympodium.

Peplis Linn. Lythraceae. 3 sp. wet places, N. temp. *P. Portula* L. occurs in Brit. It is a little annual herb, very like *Montia fontana* with minute hexamerous flrs. Self-fertilisation occurs by the bending inwards of the sta. over the stigma. The fruit is bilocular (the partition does not come up to the very apex) with many seeds, but indehiscent. When submerged the plant has a more etiolated structure and becomes perennial.

Pereskia Plum. ex Linn. Cactaceae (III). 13 sp. trop. Am., W. Ind. Leafy plants (see order). Some, *e.g. P. aculeata* Mill., climb like Rubus with recurved thorns.

Perezia Lag. Compositae (XII). 70 sp. Texas to Patagonia.

Perilla Linn. Labiatae (VI. 11). 2 sp. E. Ind., China.

Perilomia H. B. et K. Labiatae (VI. 2). 8 sp. Andes.

Periploca Tourn. ex Linn. Asclepiadaceae (I. 1). 12 sp. As., Afr., S. Eur.

Peristeria Hook. Orchidaceae (19). 5 sp. Cent. Am. Epiphytic. *P. elata* Hook. ('el spirito santo,' so called by the natives of Panama because of its resemblance to a dove) is best known. Its mechanism requires investigation.

Pernettya Gaudich. Ericaceae (II. 5). 26 sp., one Tasmania and N. Z., the rest S. Am. and Mexico.

Persea Plum. ex Linn. Lauraceae (I). 10 sp. trop. Am. The fruit of *P. gratissima* Gaertn. f., and other sp., is eaten under the name Avocada or alligator pear.

Persicaria (Tourn.) Linn. = Polygonum Tourn.

Personales (Benth.-Hooker). The 9th cohort of Gamopetalae (p. 135).

Personatae (Warming). The 5th cohort of Sympetalae (p. 137).

Persoonia Sm. Proteaceae (I). 60 sp. Austr., N. Z.

Pescatorea Rchb. f. = Zygopetalum Hook.

Petalostemon Michx. (*Kuhnistera* Lam.) Leguminosae (III. 6). 20 sp. N. Am.

Petasites (Tourn.) Linn. Compositae (VIII). 14 sp. N. temp. *P. officinalis* Moench, the butter-bur, is common in Brit. on the banks of streams &c. It spreads very largely by rhizomes. It is diœcious (cf. Tussilago, its close ally). The male head has about 30 flrs. with the usual mechanism of Compositae, the style acting as the pollen-presenter, though the ovary is no longer fertile. Occasionally a few ☿ flrs. are found. The female head consists of about 150 ♀ flrs. surrounding 1—3 ♂ flrs. Only the male flrs. secrete honey. Under the name of winter heliotrope, *P. fragrans* Presl is cultivated for its scented flrs., which appear in February.

Petrea Houst. ex Linn. Verbenaceae (II). 12 sp. trop. Am., W. Ind.

Petrophila R. Br. Proteaceae (I). 35 sp. Austr.

Petrophyes Webb et Berth. = Monanthes Haw.

Petroselinum Hoffm. = Carum Linn.

Petunia Juss. Solanaceae (IV). 14 sp. S. Am. *P. violacea* Lindl. and others are often cultivated in gardens.

Peucedanum (Tourn.) Linn. (incl. *Anethum* Tourn., *Imperatoria* Linn. *Pastinaca* Linn.). Umbelliferae (7). 120 sp. Eur., As., Afr., Am.; 4 in Brit., of which *P.* (*Past.*) *sativum* Benth. et Hook. f. is the parsnip, often cultivated for its fleshy roots. *P.* (*A*) *graveolens* Benth. et Hook. f. (Medit.) is the dill, whose fruits are used as a condiment; *P. officinale* L. (Brit.) is the sulphur-root, used in veterinary practice; *P.* (*I.*) *Ostruthium* Koch (Brit.) is also used.

Peumus Molina. Monimiaceae. 1 sp. Chili, *P. Boldus* Molina, the Boldo. The wood is hard, the bark yields a dye and the fruit is edible.

Phaca Linn. = Astragalus Linn.

Phacelia Juss. (incl. *Cosmanthus* Nolte, *Eutoca* R.Br., *Whitlavia* Harv.). Hydrophyllaceae. 80 sp. N. Am., Andes. Often cultivated as border plants and for bee-feeding. The flr. is a bee-flower with honey secreted below the ovary and guarded by stipule-like flaps at the base of the sta. The large-flowered sp. are highly protandrous, and are not self-fertilised; the smaller less protandrous and with self-fertilisation. The anther as it dehisces turns inside out, and changes its shape from ellipsoidal to spherical (*Linn. Soc. Journ.*, 1893, p. 53).

Phaedranassa Herb. Amaryllidaceae (I). 4 sp. S. Am.

Phaenocoma D. Don. Compositae (IV). 1 sp. Cape Colony.

Phajus Hassk. Orchidaceae (15). 12 sp. trop. As., Malaya, Austr., &c. Terrestrial plants.

Phalaenopsis Blume. Orchidaceae (31). 35 sp. Indo-mal. Epiphytes with flattened aerial roots.

Phalaris Linn. Gramineae (VII). 10 sp. Eur., Am. *P. canariensis* L. is the canary grass, whose seeds are used for cage-birds. *P. arundinacea* L. (reed-grass) is common in Brit.

Pharbitis Choisy = Ipomoea Linn.

Pharus P. Br. Gramineae (VI). 5 sp. trop. Am.

Phaseolus (Tourn.) Linn. Leguminosae (III. 10). 150 sp. trop. and warm temp. The floral mechanism is like that of Vicia, but complicated by the spiral coiling of the keel with the inclosed style. *P.*

multiflorus Willd. (Mexico) is the scarlet-runner, *P. vulgaris* L. the French or kidney bean. *P. Mungo* L. (*P. Max* L.) the 'green gram' of India, used like kidney beans.

Phegopteris Fée = Polypodium Linn. *P. Dryopteris* Fée = *Polyp. Dryopteris; P. polypodioides* Fée = *Polyp. Phegopteris*.

Phelypaea Tourn. ex Linn. Orobanchaceae. 2 sp. Cent. As.

Philadelphus (Riv.) Linn. Saxifragaceae (III). 13 sp. N. temp. &c. Shrubs with opp. leaves; the buds arise closely protected by the leaf-bases through which in many sp. they have to break. The flrs. are conspicuous and strongly scented. Sta. 20—40; ovary inferior, usually 4-loc. Flr. protogynous. Several sp. are grown in shrubberies under the name Syringa.

Philesia Comm. ex Juss. Liliaceae (X). 1 sp. S. Chili.

Phillyrea Linn. Oleaceae (I. 3). 6 sp. Medit.

Philodendron Schott. Araceae (V). 120 sp. trop. Am. Most are shrubs, usually climbing and often epiphytic, with both clasping roots and aerial roots reaching the soil (see order). The pinnation of the leaf is due to a delayed development of the portions between the ribs, and not to a process such as occurs in Monstera (q.v.). Monœcious.

Philydraceae. Monocotyledons (Farinosae). 3 gen. with 4 sp. Indo-mal., Austr. See *Nat. Pfl.* Placed in Coronarieae by Benth.-Hooker, in Liliiflorae by Warming.

Phleum Linn. Gramineae (VIII). 10 sp. temp. except Austr. *P. pratense* L. the timothy-grass (Brit.) is a valuable fodder.

Phlomis Linn. Labiatae (VI. 4). 65 sp. Medit. to China. The upper lip of the flr. is raised by an entering insect.

Phlox Linn. Polemoniaceae. 30 sp. N. Am., Siberia. Favourites in horticulture.

Phoenix Linn. Palmae (I. 1). 12 sp. trop. Afr., As. The chief is *P. dactylifera* L., the date palm of Afr. and S.W. As. It has a columnar stem covered with old leaf-bases; the leaves are pinnate. Flrs. diœcious; the Arabs fertilise the ♀ spadix by hanging a ♂ over it. Fruit a berry; seeds with hard (cellulose) endosperm. The date-palm yields fruit, wine, sugar, hats, mats, thatch, and many other products.

Pholidia R.Br. Myoporaceae. 57 sp. Austr.

Pholidota Lindl. Orchidaceae (7). 20 sp. Indo-mal., S. China.

Phormium Forst. Liliaceae (III). 2 sp. N.Z. Leaves isobilateral. The leaf of *P. tenax* Forst. furnishes the valuable fibre called New Zealand flax.

Photinia Lindl. Rosaceae (II. 4). 17 sp. S.E. As., N. Am. [*P. japonica* Thunb. = *Eriobotrya japonica*.]

Phragmites Trin. Gramineae (X). 3 sp., 1 Argentine, 1 trop. As. and 1 cosmop. (incl. Brit.), *P. communis* L. the common reed. It has a creeping rhizome and tall upright stem with a dense panicle of spikelets. The lowest flr. of the spikelet is ♂, the rest are ☿. A few cm. above the leaf-sheath are three transverse dents in the leaf (Teufelsbiss); these are due to pressure at the time when the rolled up blade is still in the sheaths of older leaves.

Phryma Linn. Phrymaceae. 1 sp. As., N. Am.

Phrymaceae. Dicotyledons (Sympet. Tubiflorae). Only genus Phryma; placed in Verbenaceae by Benth.-Hooker, but separated by Briquet in *Nat. Pfl.*; the chief distinction is the erect orthotropous ovule of P.; no transitions occur between this and other Verbenaceae.

Phrynium Loefl. Marantaceae. 20 sp. trop. As. and Afr.

Phuopsis Benth. et Hook. f. Rubiaceae (II. 21). 1 sp. Caucasus. Flrs. in heads, suited to Lepidoptera and bees. They are said to be explosive, the bud remaining closed and the style bursting out on contact with an insect.

Phygelius E. Mey. Scrophulariaceae (II. 6). 1 sp. S. Afr.

Phylica Linn. Rhamnaceae. 65 sp. S. Afr. and neighbouring Is. Mostly xerophytic shrubs, often of heath-like habit with leaves rolled back (cf. Empetrum).

Phyllachne Forst. Candolleaceae. 9 sp. Austr., N. Z., S. Am.

Phyllanthus Linn. Euphorbiaceae (A. I. 1). 400 sp. temp. and trop., exc. Eur. and N. As. The sp. of the trop. Am. sub-genus *Xylophylla* have flat green phylloclades bearing the flrs. on their margins. The ultimate shoots in the sub-genus *Euphyllanthus* look like pinnate leaves. In *P. cyclanthera* Baill. the ♂ flr. has its 3 sta. united into a synandrium with a ring-like anther at the top.

Phyllarthron DC. Bignoniaceae (IV). 6 sp. Madag., Mascarenes. The leaf is reduced to a jointed winged petiole.

Phyllis Linn. Rubiaceae (II. 17). 1 sp. Canaries, Madeira (p. 148).

Phyllocactus Link. Cactaceae (I). 13 sp. trop. Am., often epiphytic. Flat-stemmed plants (see order).

Phyllocladus Rich. Coniferae (Taxaceae, 4; see C. for genus characters). 3 sp. Tasm., N. Z., Borneo (celery pine). The 'short shoots' are represented by flat green leaf-like structures—phylloclades—whose stem-nature is easily recognised by their position in the axils of the scale leaves on the 'long shoots.' The edges of the phylloclades also bear scales. The flrs. (mon- or di-œcious) occupy the position of phylloclades. Each cpl. has one axillary erect ovule. The seed has a small basal aril. The timber is useful: the bark of *P. trichomanoides* D. Don is used for tanning.

Phyllodoce Salisb. = Bryanthus S. G. Gmel. *P. coerulea* Bab. = *B. taxifolius*.

Phylloglossum Kunze. Lycopodiaceae. 1 sp. *P. Drummondii* Kunze, Austr. and N. Z. The embryo forms a protocorm (see order), which produces a crown of sterile leaves and a short unbranched stem, bearing at its apex a single cone of sporangia, like the cone of Lycopodium. "At the end of the growing season a new protocorm is formed. This arises directly from the apex of the old one where no strobilus is developed, but in the latter case grows out upon a sort of peduncle from near the base of one of the leaves" (Campbell). The prothallus is subterranean.

Phyllospadix Hook. Potamogetonaceae. 2 sp. W. coast of N. Am. Diœcious.

Physalis Linn. Solanaceae (II). 45 sp. Am. *P. Alkekengi* L. (winter cherry) in Eur. and As. The berry of this sp. is edible, also that of *P. peruviana* L. (strawberry or gooseberry tomato, or cape gooseberry). It is enclosed in the bladdery persistent calyx, which becomes red.

Physospermum Cusson. Umbelliferae (5). 5 sp. Eur., W. As.

Physostegia Benth. Labiatae (VI. 4). 3 sp. N. Am.

Physostigma Balf. Leguminosae (III. 10). 2 sp. trop. Afr. *P. venenosum* Balf. is the ordeal bean of Calabar. The floral structure is peculiar; the keel is spurred.

Phytelephas Ruiz et Pav. Palmae (V). 4 sp. trop. Am. This genus and Nipa are widely different from the other palms, exhibiting affinities to Pandanaceae and Cyclanthaceae (see *Nat. Pfl.*). P. is a short-stemmed palm with large pinnate radical leaves, and diœcious infls. The ♂ infl. is a sausage-shaped spadix; the flr. has an irregular perianth and ∞ sta. with long filaments. The ♀ spadix is simple, with a spathe of several leaves, and about 6 flrs.; the flr. has an irregular perianth (an outer whorl of 3 and an inner of 5—10 longer leaves), numerous staminodes and usually a 5-loc. ovary with long style and stigmas. Each flr. gives a berry, and the actual fruit consists of 6 or more of these united together. The outer coat is hard, with woody protuberances. Each partial fruit contains several seeds; the endosperm (cellulose) is very hard (vegetable-ivory) and is used for turning into billiard balls &c. (Compare this fruit with those of Pandanus and Carludovica.]

Phyteuma Linn. Campanulaceae (I. 1). 40 sp. Medit., Eur., As. Two sp. of rampion, *P. orbiculare* L. and *P. spicatum* L. occur in the south of England. The floral mechanism is interesting (see order). The flrs. are comparatively small, and are massed together in heads. A tube is formed by the coherence of the tips of the long thin petals, within which the anthers are held. The style pushes up through this and drives the pollen gradually out at the end, where it is exposed to insects. Finally the style emerges, the stigmas open and the petals separate and fall back. [Compare carefully with Campanula, Jasione and Compositae.]

Phytocrene Wall. Icacinaceae 7 sp. India to New Guinea. They are twining shrubs, with very large vessels in the stem. If the stem be cut a considerable quantity of water escapes, which is drunk by the Malabar natives. The flrs. are diœcious.

Phytolacca Tourn. ex Linn. (incl. *Pircunia* Bert.). Phytolaccaceae. 11 sp. Am., Afr. Herbs with fleshy roots, or shrubs or trees. Flrs.

regular; P 5, A 10—20, G 7—10 or (7—10); in the latter case the fruit is a berry, in the former an aggregate of achenes or drupes.

Phytolaccaceae. Dicotyledons (Archichl. Centrospermae). 20 gen. with 55 sp. chiefly trop. Am. and S. Afr. Herbs, shrubs, or trees, with racemose or cymose infls. of regular inconspicuous ☿ flrs. P 4—5, A 4—5 or more (to ∞), $\underline{G}$ 1—∞ or (1—∞). Ovules 1 in each cpl., amphi- or campylo-tropous. Drupe or nut, rarely capsule. Seed with perisperm, often arillate. The flrs. exhibit great variety in structure, owing to branching of sta. and different numbers and arrangements of cpls. (see *Nat. Pfl.*). *Chief genera:* Seguiera, Rivina, Phytolacca. Placed in Curvembryae by Benth.-Hooker and Warming. For relationships see Caryophyllaceae.

Picea Link. *Synonymy: P. vulgaris* Link (*Pinus Abies* L.) = *P. excelsa* Link; *P. canadensis* Link = *Tsuga canadensis; P. Pinsapo* Loud. = *Abies Pinsapo; P. rubra* A. Dietr. = *P. nigra* Link.

Coniferae (Arauc. 1 b; see C. for genus characters). 12 sp. N. temp. Long shoots only with needle leaves. Flrs. single. Cones ripening in one year. *P. excelsa* is the Norway spruce or spruce-fir, found in Eur. from the Pyrenees to 68° N. It furnishes valuable wood, resin, and turpentine. *P. alba* Link (silver fir, N. Am.) and others are also valuable.

Picris Linn. Compositae (XIII). 36 sp. Medit., N. tem., Abyss. 2 in Brit. Like Leontodon.

Pilea Lindl. Urticaceae (2). 100 sp. trop., several cultivated under the name artillery plant, given to them on account of the little smoke-like puffs of pollen ejected by the exploding sta. (cf. Urtica).

Pilocarpus Vahl. Rutaceae (V). 12 sp. trop. Am., W. Ind. The leaves of *P. pennatifolius* Lem. are the officinal 'folia Jaborandi.'

Pilocereus Lem. = Cereus Mill.

Pilostyles Guill. Rafflesiaceae. 8 sp., esp. trop. Am. Parasites on Leguminosae.

Pilularia Linn. Marsiliaceae. 3 sp. N. and S. temp. *P. globulifera* L., the pill-wort, is found on the margins of lakes in Brit. There is a creeping rhizome bearing roots on the lower surface and linear erect leaves on the upper. The sporocarp is a pea-shaped structure, borne on the ventral side of a leaf-stalk. It has a hard outer coat and consists of four sori, each containing both micro- and mega-sporangia. The life history is like that of Marsilia.

Pimelea Banks et Soland. Thymelaeaceae. 80 sp. Austr., Tasm., N. Z., Timor. The flrs. are in heads and are, in some sp. at least, protandrous with movement of sta. outwards.

Pimenta Lindl. Myrtaceae (I). 5 sp. trop. Am. The unripe fruits of *P. officinalis* Lindl., rapidly dried, form allspice.

Pimpinella (Riv.) Linn. Umbelliferae (5). 75 sp. cosmop. (exc. Austr.). 2 in Brit.; *P. Saxifraga* L. (burnet-saxifrage) is very common. *P. Anisum* L. (Medit.) is the Anise, whose fruits (aniseed) are largely used in flavouring.

Pinanga Blume. Palmae (IV. 6). 40 sp. Indo-mal.

Pinguicula Tourn. ex Linn. Lentibulariaceae. 30 sp. N. extra-trop., Andes, Antarctic zone; 3 in Brit. (butterwort), of which *P. vulgaris* L. is common. It has a rhizome with a rosette of radical leaves arranged in $\frac{5}{8}$ phyllotaxy. The leaves are covered with glands, some sessile, some on stalks, secreting a sticky fluid to which small insects adhere. Rain washes them against the edge of the leaf, which is slightly upturned: when stimulated by the presence of proteid bodies it rolls over upon itself and encloses them, and then the sessile glands secrete a ferment, digest the prey, and absorb the products (see p. 178), after which the leaf unrolls again. *P. lusitanica* L. is found on the western shores of Brit. and is one of a few sp. which have migrated thus far up the Atl. coasts (its home is Portugal).

Pinus (Tourn.) Linn. *Synonymy: P. Abies* L. (*P. excelsa* Lam.) = *Picea excelsa; P. alba* Ait. = *Picea alba; P. balsamea* L. = *Abies balsamea; P. Cedrus* L. = *Cedrus Libani; P. Douglasii* Lamb. = *Tsuga Douglasii; P. Larix* L. = *Larix europaea; P. maritima* Lam. = *P. Pinaster; P. nigra* Ait. = *Picea nigra; P. Picea* L. = *Abies pectinata.*

Coniferae (Arauc. I b: see C. for genus characters). 70 sp. N. temp. and on Mts. in the N. tropics. They are evergreen, resinous trees with both long and short shoots (sec Coniferae). If a tree be examined in winter the main axes will be found each with a group of buds at the end, one terminal, the rest lateral. They are covered with resinous scale leaves. Each gives rise in spring to a 'long shoot' or shoot of unlimited growth; if it be the main axis of all, we see the terminal bud continue it, forming a year's growth before branching in a similar way again. The large branches thus form rough whorls marking each year's growth. On the stem of a long shoot no green leaves are directly borne, but only scales, first the bud scales above mentioned and then others in whose axils arise the 'short shoots', or shoots of limited growth. Each of these has a few scale leaves at the base of a very short stem and ends with 2 or more green leaves of needle shape. When there are two, their upper flat sides face one another. These needle leaves exhibit xerophile characters in a high degree; they are thick in proportion to surface exposed, they have a very stout epidermis with a hypoderm of thick walled tisue under it, and the stomata are placed at the bottom of deep pits; the intercellular spaces too are very small.

The flrs. take the form of the familiar cones, the ♂ being grouped together in spikes. Each flr. whether ♂ or ♀, occupies the position of a short shoot and is of limited growth—an axis with a few scale-leaves below bearing a number of sporophylls. In the ♂ there are many sta., each with two pollen-sacs on the under side; the pollen is loose and powdery, and each grain has two bladdery expansions of the cuticle helping it to float in the air. In the ♀, the cpls. themselves are very small, but the ovuliferous scales, which show at the outside of the cone, are very large, and each bears two ovules at its base, with the micropyles facing the axis. The ♀ cones take 2 to 3 years before the seeds are ripe. In May of the first year, the first stage may be seen—young cones, about 1 cm. long, in the position of short shoots near the tip of the lengthening axis. Microscopic examination of these (see text-books) shows that the ovules are not ripe for fertilisation. In June (the time varies from year to year according to season) pollination takes place. The ♂ cones shed their pollen in great quantities, so that in a pine forest the air is often full of it (if it rain, the phenomenon of 'showers of sulphur' may occur), and the wind carries it about. At the same time the ovuliferous scales spread apart. If a grain fall between two of them it slips down to the micropyle of an ovule, where it becomes held by the sticky fluid then exuding. After a short time the ♀ cones close up again. The pollen grain is brought into contact with the nucellus by the drying up of the mucilage; it forms a short pollen-tube, and then a resting period comes on. Next year in May or June the ♀ cone has become a fat green body about 3 cm. long, with the ovules ready for fertilisation; the pollen-tubes now recommence growth and reach the ova. Then in the third year the cone is mature—a hard woody cone containing the seeds between the scales. Each seed contains an embryo with a whorl of cotyledons, embedded in rich endosperm, and has a hard testa. To the end of this is attached a thin membranous wing, derived from the ovuliferous scale. In dry weather the cone opens and the seeds are blown away by the wind. In germination the seed is lifted up above the earth by the growing plant and the cotyledons remain inside the testa till all the reserves are exhausted. It is noteworthy that they are green whilst in the seed, though in darkness—an exception to the rule that chlorophyll requires light for its formation. During the first year no short shoots are formed, and the seedling has green leaves borne directly on the main stem.

The pines are amongst the most valuable of all plants and are cultivated on an enormous scale, chiefly for their timber, which is easily worked, and resinous products. The resin renders the timber very resistent to decay, &c.

Some of the more important sp. will now be mentioned.

I. *PINASTER* Endl. Visible part of fruit scale more or less pyramidal with central boss.

§ 1. *Pinea* (short shoot with 2 or rarely 1 needles): 20 sp. *P. sylvestris* L., the Scotch fir, the only British sp., occurs in Eur. to 68° N., in Asia to 66° N., and as far south as Spain and Italy (alpine). The wood (yellow deal) is largely used in the arts; turpentine is obtained by tapping the tree. The resin exudes and is distilled; the distillate is oil of turpentine, the remainder rosin. Tar and pitch are correspondingly the products of destructive distillation in closed chambers. *P. Pumilio* Haenke (*P. montana* Mill.) is a shrubby decumbent sp., Pyrenees to Caucasus. *P. Pinea* L. (Medit.), the stone pine, furnishes edible seeds ('pignons'). *P. Laricio* Poir. (S. Eur.) is the Corsican pine. *P. Pinaster* Ait., the cluster pine or pinaster (Medit.) is a valuable tree. It grows well near the sea, and large areas of the Landes of S. France are planted with it. It furnishes much of the turpentine &c. in use. *P. echinata* Mill. the short leaved or yellow pine is a valuable N. Am. sp.

§ 2. *Taeda* (needles 3, triangular in section): 16 sp. *P. Taeda* L., is the loblolly or frankincense pine of the southern U. S. It yields turpentine. *P. palustris* Mill. (*P. australis* Michx.) is the pitch-pine of the U. S. It yields timber and turpentine. Other sp., *e.g. P. ponderosa* Dougl. and *P. rigida* Mill., are also known by the name of pitch-pine.

II. *STROBUS* Spach. Visible part of fruit scale with terminal boss. Needles usually 5 in each short shoot. 20 sp.

§ 1. *Eustrobus* (cones hanging, seeds winged): *P. Strobus* L., the Weymouth pine (East N. Am.), a timber tree; *P. Lambertiana* Dougl., the giant sugar pine of the Western States; *P. excelsa* Wall., the Bhotan pine (E. India).

§ 2. *Cembra* (cones erect or drooping, seeds not winged); *P. Cembra* L. the Siberian cedar (Alps, Carpathians, Ural, Siber.) has edible seeds and valuable wood; *P. flexilis* James (N. Am.) &c. [For further details see *Nat. Pfl.*, Veitch's *Manual of Coniferae*, Müller's *Select Extratrop. Plants*, &c.]

Piper Linn. (incl. *Chavica* Miq.). Piperaceae. 600 sp. trop. mostly climbing shrubs. Flrs. in sympodial spikes, the bracts closely appressed to the axis. The fruit is a berry. That of *P. nigrum* L. gathered before it is ripe and dried, forms a black peppercorn; or if the outside be removed by maceration, a white one. *P. Cubeba* L. f. is the cubebs, *P. Betle* L. the Betel pepper (see Areca). See *Treas. of Bot.*

Piperaceae. Dicotyledons (Archichl. Piperales). 7 gen. with 1050 sp. trop. Plants of low organisation. Herbs or shrubs with undivided leaves with or without stipules; the leaves have a pungent taste. Flrs. naked, in spikes. Sta. 1—10. Cpls. (1—4); ovary 1-loc. with 1 basal orthotropous ovule. Seeds with dense perisperm round the endosperm; embryo small. The stem-anatomy is interesting. Piper is economically useful. *Chief genera:* Piper, Peperomia. Placed in Micrembryae by Benth.-Hooker (who include Saururaceae in P.), in Polygoniflorae by Warming.

Piperales. The 1st cohort of Archichlamydeae (p. 127).

Piptadenia Benth. Leguminosae (I. 5). 40 sp. trop., esp. Am. *P. rigida* Benth. (Brazil) yields Angico gum used like gum-arabic.

Piptanthus Sweet. Leguminosae (III. 2). 1 sp. Himalaya.

Pircunia Bert. = Phytolacca Linn.

Pirola Neck. = Pyrola Tourn.

Pirus Hall. = Pyrus Tourn.

Pisonia Plum. ex Linn. Nyctaginaceae (2). 40 sp., chiefly trop. The flrs. are generally unisexual. The anthocarp is glandular and is one of the few fruits which are able to cling to feathers. Forbes states that on Keeling Island the fruits adhere to the feathers of herons in such quantities as sometimes absolutely to cripple them, or even to cause their death.

Pistacia Linn. Anacardiaceae (III). 5 sp. Medit., 3 E. As., 1 Mexico. Flrs. diœcious, apetalous or naked. Fruit a drupe. *P. Terebinthus* L. yields Chian turpentine, *P. Lentiscus* L. the resin called mastic. The fruits of *P. vera* L. are eaten under the name Pistachio nuts.

Pistia Linn. Araceae (VIII). 1 sp. trop. Am., Afr., As., *P. Stratiotes* L., a floating water-plant, but rarely anchored by its roots to the soil, and therefore often blown about by wind. It is of sympodial structure, but the internodes remain short and bear a rosette of large leaves; these sleep at night, moving upwards from the nearly horizontal position which they occupy by day. The continuation shoots of the sympodium are axillary, but beside each leaf arises a stolon which grows out along the water and gives rise to a new plant. The infl. is small and monœcious; above is a whorl of ♂ flrs., each with a synandrium of 2 sta.; below is a ♀ flr. of 1 cpl. Both are naked. P. is a link between Lemnaceae and Araceae (q.v.).

Pisum (Tourn.) Linn. Leguminosae (III. 9). 6 sp. Medit. W. As. *P. sativum* L. is the common pea. The floral mechanism resembles that of Lathyrus, but differs much in detail (see Müller).

Pitcairnia L'Hérit. Bromeliaceae (2). 70 sp. S. Am. Most are terrestrial; many form stolons at the base.

Pithecolobium Mart. Leguminosae (I. 1). 110 sp. trop. Stipules often thorny. Fruit often coiled up like that of Medicago. *P. Saman* Benth. (trop. S. Am.) is the rain tree, so called because of a legend that it was always raining under its branches. The ejections of juice by the Cicadas are responsible for this (cf. Acer, Andira).

Pittosporaceae. Dicotyledons (Archichl. Rosales). 10 gen. with 90 sp., confined (exc. Pittosporum) to Austr. Trees or shrubs, often climbing, with alt., leathery, evergreen, usually entire, exstip. leaves. Resin is present in large quantity in passages at the outer side of the bast. Flrs. ☿, regular, 5-merous; sta. hypogynous; cpls. 2 or more, forming a 1-loc. or multi-loc. ovary with parietal or axile placentation, and 2-ranked ∞ anatropous ovules; style simple. Fruit a capsule or berry with albuminous seeds. *Chief genera:* Pittosporum, Billardiera, Sollya. The relationships are very obscure (see *Nat. Pfl.*); it is placed in Polygalinae by Benth.-Hooker, and in Saxifraginae by Warming.

Pittosporum Banks. Pittosporaceae. 70 sp. trop. and subtrop., Canaries to Japan and Sandwich Is. The seeds of some sp. are sticky. Some yield useful timber.

Plagianthus Forst. Malvaceae (II). 10 sp. Austr., N. Z.

Plagiocheilus Arn. Compositae (VII). 7 sp. S. Am.

Planera J. F. Gmel. Ulmaceae. 1 sp. U. S. *P. aquatica* J. F. Gmel., a useful timber tree.

Plantaginaceae. Dicotyledons (Sympet. Plantaginales). 3 gen. with 200 sp. cosmop. (See genera.) Annual or perennial herbs; leaves without distinction into stalk and blade, exstip. Flrs. usually in heads or spikes, inconspicuous, usually ☿, regular, without bracteoles, wind- or partly insect-fertilised. K (4), diagonally placed; C usually (4), membranous; A 4, with very long filaments and versatile anthers containing much powdery pollen; $\underline{G}$ usually (2), 2-loc., with 1—∞ semi-anatropous ovules on axile placentae. Fruit a membranous capsule, opening with a lid cut off by a peripheral dehiscence, or sometimes, a nut surrounded by the persistent calyx. Embryo straight, in fleshy endosperm. *Genera:* Plantago, Littorella, Bougueria. See P. and L. for details. The relationships of the P. are difficult to make out. The flr. is usually regarded as derived from a 5-merous type in the same way as that of Veronica, and most authors agree in regarding the P. as degraded forms allied to Scrophulariaceae, Labiatae, &c. The wind-pollination of the flr. is also an evidence of this. Benth.-Hooker place the P. as an anomalous order after Labiatae, Warming places them in Personatae.

Plantaginales. The 6th cohort of Sympetalae (p. 140).

Plantagineae. (Benth.-Hooker) = Plantaginaceae.

Plantago (Tourn.) Linn. Plantaginaceae. About 200 sp. cosmop.; 5 in Brit. The Brit. sp. will serve as good illustrations of the genus. *P. major* L. (greater plantain) is a perennial with a thick root and a rosette of large erect leaves. In the axils of these arise the infls. (spikes). The flr. is markedly protogynous, the stigmas protruding from the bud; the sta. appear later. Wind-pollination is the rule, as the structure of the flrs. indicates (p. 85), but insects sometimes visit them for pollen. The fruit-spikes are often given as food to cage-birds. *P. media* L. (hoary plantain) shows similar general features, but the leaves lie flat on the ground (hence it is a most troublesome weed in lawns, &c.); they exhibit the 3/8 phyllotaxy (p. 45) very clearly. The flr. is more conspicuous than that of *P. major* and has a pleasant scent, and though primarily wind-pollinated, is largely visited for pollen in fine weather by drone-flies and bees. It is sometimes gynodiœcious (cf. Labiatae). *P. lanceolata* L. (rib-wort plantain) has narrow erect leaves, and flrs., like those of the last sp., also gynodiœcious. *P. Coronopus* L. (buck's-horn plantain) is a xerophytic sp. with hairy leaves, growing in sandy places. Many S. Am. sp. show very marked xerophilous characters—dense tufting, small hairy leaves, often grooved on the lower surface (cf. Ericaceae), &c. *P. maritima* L. (the sea-side plantain) has linear fleshy leaves (p. 169): it is frequently found at high levels in the Scottish Mts. (p. 187), though rarely in the intermediate regions.

The seeds of many sp. swell up when wetted and become mucilaginous (cf. Linum). Those of *P. Psyllium* L. (Medit.) are used in various ways in silk and cotton manufactures on account of this property; they have also been used in medicine.

If the young growing infl. of a P. be vigorously shaken, the spike when left to itself droops and only becomes erect again after a considerable time. This is due to the fact that the strain stretches the young cell walls beyond their limit of elasticity (see Sachs' *Lectures on the Physiology of Plants*, p. 220).

Platanaceae. Dicotyledons (Archichl. Rosales). Only genus Platanus (q.v.). The relationships of P. are obscure; it is placed in Unisexuales by Benth.-Hooker, in Saxifraginae by Warming, and apparently comes nearest to Rosaceae and Hamamelidaceae.

Platanthera Rich. = Habenaria Willd.

Platanus (Tourn.) Linn. Platanaceae. 4 sp. N. temp. The plane-tree, *P. orientalis* L., is well known. The bark scales off every year, leaving a smooth surface. The axillary bud is developed under the base of the petiole, which fits over it like an extinguisher. The stipules are united round the stem. Flrs. monœcious in pendulous heads, wind-fertilised. K 4 or 3. Sta. 4 or 3, opposite sepals. Cpls. 4 or 3, apocarpous. Ovules orthotropous, pendulous. Multiple fruit, each cpl. giving a caryopsis, often winged. Seed albuminous. The wood of the plane is useful, and also that of the buttonwood of N. Am. *P. occidentalis* L.

Platycerium Desv. Polypodiaceae. 5 sp. Afr., Malaya, Austr. They are epiphytic, but sometimes grow on steep rock surfaces, and exhibit a very interesting structure. The rhizome is short and bears alternately leaves of two kinds. The young leaves are protected by hairs. Of the two kinds of leaves, the one stands more or less erect (the 'mantle' leaf) the other is pendulous, usually much branched and bears the sporangia in irregular areas on its lower surface. Assimilation is chiefly carried on by the pendulous leaves. Two types of mantle leaf occur, represented in *P. grande* J. Sm. and *P. alcicorne* Desv., the two common sp. In the former the base of the leaf, which is unbranched, clings closely to the supporting trunk, whilst the upper part spreads out and makes a niche in which humus collects; in this the roots ramify and absorb food. This plant grows to a great size. In *P. alcicorne* on the other hand the whole of the mantle leaf clings to the support, and the only humus-supply the roots have is that furnished by the decay of old mantle leaves and perhaps of the tree bark. This sp. is comparatively small, but grows in great colonies, owing to adventitious budding from the roots. In both sp. the bases of the leaves are rather fleshy and act as water stores.

The stag-horn ferns are favourites in hot-houses. Beside the two mentioned, *P. Wallichii* Hook. and *P. Willinckii* Moore are also grown. They have the habit of *P. grande.*

Platycodon A. DC. Campanulaceae (I. 1). 1 sp. E. As.

Platylobium Sm. Leguminosae (III. 3). 3 sp. Austr. Pods flat.

Platystemon Benth. Papaveraceae (II). 1 sp. W. N. Am., *P. californicus* Benth. Leaves in apparent whorls (see order).

Platystigma Benth. Papaveraceae (II). 3 sp. California, Oregon. Leaves as in Platystemon.

Plectocomia Mart. et Blume. Palmae (III. 5). 6 sp. Indo-mal. Climbers like Calamus with hooked leaves.

Plectranthus L'Hérit. Labiatae (VII). 70 sp. trop. Old World.

Plectritis DC. = Valerianella Tourn.

Plectronia Linn. Rubiaceae (II. 11). 80 sp. trop. Old World. Some have axillary thorns.

Pleione D. Don = Coelogyne Lindl.

Pleroma D. Don = Tibouchina Aubl.

Pleurothallis R. Br. Orchidaceae (12). 400 sp. trop. Am.

Pluchea Cass. Compositae (IV). 30 sp. trop. and subtrop.

Plumbaginaceae. Dicotyledons (Sympet. Primulales). 10 gen. with 280 sp. cosmop., but esp. on salt steppes and sea-coast. 2 Brit. genera. Perennial herbs or shrubs with narrow leaves, on whose surface water glands occur, or sometimes chalk glands (cf. Saxifraga). The infl. is of various types, racemose and cymose (see Plumbago, Ceratostigma, Statice, Armeria), bracteolate. Flrs. regular, ☿, 5-merous, the odd sepal posterior. Calyx persistent. Corolla often nearly polypetalous, convolute. Sta. 5, epipetalous and opposite the petals. Ovary superior, 1-loc., with basal placenta. One anatropous ovule, whose stalk projects up to the top of the loc. and thus causes the micropyle to be directed upwards. Styles or stigmas 5. Fruit a nut; embryo straight, in floury endosperm. The order is distinguished from Primulaceae by the ovary and styles. *Chief genera:* Plumbago, Ceratostigma, Acantholimon, Armeria, Statice, Limoniastrum. Placed in Primulales by Benth.-Hooker, in Primulinae by Warming.

Plumbago Tourn. ex Linn. Plumbaginaceae. 10 sp. Medit. and trop. Racemose infl. Calyx with glandular hairs, aiding seed-dispersal.

Plumeria Tourn. ex Linn. Apocynaceae (I. 3). 40 sp. trop. Am. Several are cultivated for the beauty and sweetness of the flrs.

Poa Linn. Gramineae (X). 100 sp. temp.; 8 in Brit. (meadow grass). Many are useful pasture-grasses.

Pocockia Ser. = Trigonella Linn.

Podalyria Lam. Leguminosae (III. 2). 20 sp. S. Afr.

Podocarpus (L'Hérit.) Pers. Coniferae (Taxac. 3; see C. for genus characters). 40 sp. E. As. and S. temp. and trop. Dioecious. The ♀ has a peculiar structure. There are usually three pairs of scales, decussate. One of the middle pair projects above all the rest, bearing an anatropous ovule. The other 5 are sometimes united to form the so-called receptacle. The fruit usually consists of a fleshy mass (the 'receptacle') bearing an arillate seed. In some sp. the sterile scales do not become fleshy. The timber is valuable.

Podochilus Blume. Orchidaceae (10). 12 sp. Indo-mal. Epiphytes.

Podolepis Labill. Compositae (IV). 13 sp. Austr.

Podophyllum Linn. Berberidaceae. 5 sp. N. temp. In *P. peltatum* L. the rhizome sends up yearly a shoot bearing two large peltate leaves, which hang down in the young condition like a closed umbrella. A drug is prepared from the rhizome. Fruit a berry, whose flesh consists chiefly of the placenta which grows up round the seeds (wrongly termed an aril).

Podostemaceae. Dicotyledons (Archichl. Rosales). 22 gen. with 100 sp. trop. A remarkable order of plants (p. 163) adapted to life in rushing (*i.e.* also generally rising and falling) water; they grow on rocks in rivers and are very local in distribution, contrary to the usual rule in water-plants. The morphology of the vegetative organs is extremely varied and complex. The seeds are shed on the rocks during the drier season of the year, and germinate when the rains cause them to be submerged. The primary axis is usually small, and from the base there buds out a green *thallus*, usually of adventitious root nature (pp. 30, 39). In Tristicha, Podostemon, &c. it is ± filamentous, creeping on the rock, and attached to it by hairs or exogenous projections termed *haptera*. In Dicraea it is ± freely swimming and often ribbon-like or sea-weed-like. In Hydrobryum it is ± flattened, creeping, lichen-like. In Lawia there is a flat creeping thallus of shoot nature, and other complications occur in Castelnavia and others. From the thallus in most cases endogenous secondary shoots arise, and remain vegetative (leaves alt., simple or much divided) till the latter part of the rainy season, when they form flrs. which open when exposed by the fall of the water. The plants die after shedding their seed, unless an early rise of water occurs. Their outer tissues are usually very siliceous. Flrs. simple, ☿ (dioecious in Hydrostachys, which is better placed in a separate order), regular or not, hypogynous; P3–5 or ∞, or (3–5), A1–2–∞, $\underline{G}$ usually (2) 2-loc. with thick axile placenta. The more dorsiventral the vegetative organs, the more dorsiventral in general is the flr., the phenomenon showing progressively in perianth, androeceum, gynoeceum, fruit, seed, and embryo. Ovules ∞ (exc. Farmeria), anatropous. Capsule; exalbuminous seeds. *Chief genera:* Tristicha, Lawia, Rhyncholacis, Mourera, Podostemon, Dicraea, Hydrobryum, Castelnavia. Placed in Multiovulatae Aquaticae by Benth.-Hooker, Saxifraginae by Warming. [For full details see Willis in *Ann. Perad.* 1, 1902 and literature there quoted.]

Pogostemon Desf. Labiatae (VI. 12). 32 sp. Indo-mal., Japan. *P. Patchouly* Pellet yields the well-known perfume by distillation.

Poinciana Tourn. ex Linn. Leguminosae (II. 7). 3 sp. trop. Afr. and As. *P. regia* Boj. is cultivated as an ornamental tree (Flamboyante).

Poinsettia R. Grah. = Euphorbia Linn.

Polanisia Rafin. = Cleome Linn.

Polemoniaceae. Dicotyledons (Sympet. Tubiflorae). 8 gen. with about 200 sp., chiefly N. Am.; a few in Chili, Peru, Eur., N. As. Herbs (rarely shrubby below), glabrous or shortly hairy, with usually opp. exstip. leaves. Flrs. in cymes (sometimes condensed into involucrate heads), ☿, regular or slightly zygomorphic, with or without bracteoles. K (5), valvate or imbricate, persistent; C (5), bell- funnel- or plate-shaped, usually convolute; A 5, epipetalous, alt. with petals; $\underline{G}$ (3) or rarely (2—5), on a disc, multiloc., with simple style more or less lobed at tip. Ovules 1—∞ in each loc., anatropous, sessile. Fruit usually a loculicidal capsule. Embryo straight, in endosperm. *Chief genera:* Cobaea, Cantua, Phlox, Collomia, Gilia, Polemonium (mostly favourite border plants). Placed in Polemoniales by Benth.-Hooker, in Tubiflorae by Warming.

Polemoniales (Benth.-Hooker). The 8th cohort of Gamopetalae (p. 135).

Polemonium (Tourn.) Linn. Polemoniaceae. 14 sp. Eur., N. As., N. Am. *P. caeruleum* L. (Jacob's ladder) in Brit., but rare. The honey is protected by hairs at the base of the sta. (cf. Hydrophyllaceae).

Polianthes Linn. Amaryllidaceae (II). 3 sp. Mexico. *P. tuberosa* L. (tuberose) is largely cultivated for its scented flrs.

Polyalthia Blume. Anonaceae (3). 70 sp. Old World trop.

Polycarpicae (Warming). The 8th cohort of Choripetalae (p. 137).

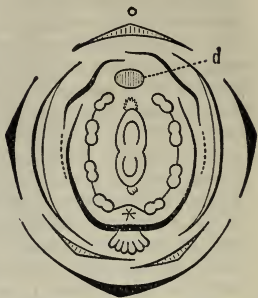
Polycarpon Loefl. Caryophyllaceae (II. 3). 7 sp. temp. and subtrop. *P. tetraphyllum* L. (polycarp or allseed) in Brit.

Polycnemum Linn. Chenopodiaceae (1). 5 sp. Eur. The structure of the fruit is curious, a ridge developing at its apex after fertilisation.

Polygala (Tourn.) Linn. Polygalaceae. 450 sp. cosmop. exc. N. Z., Polynes., and Arctic zone. A few have stipular thorns. *P. vulgaris* L. (milk-wort) is common on moors in Brit. The flrs. owe their conspicuousness to the two coloured sepals; they occur in three colours, red, white, and blue, usually on different plants but sometimes on the same one. The essential organs in most sp. are contained in the keel and emerge from it, as in Leguminosae, when it is depressed by a visiting insect. *P. Senega* L. (Senega snake-root) in N. Am. is medicinal.

Polygalaceae. Dicotyledons (Archichl. Geraniales). 10 gen. with 700 sp., cosmop. exc. N. Z., Polynes., and Arctic zone. Herbs, shrubs, or small trees with simple entire alt. opp. or whorled usually exstip. leaves; the stipules when present are usually thorny or scaly.

Infl. a raceme, spike, or panicle, with bracts and bracteoles. Flr. diplochlam., medially zygomorphic. K usually 5, rarely (5), the 2 inner sepals (*alae*) often large and petaloid; C 5, rarely all present usually only 3—the lowest and two upper—more or less joined to sta.-tube, the median anterior petal keel-like and often with a terminal brush; A in two 5-merous whorls, usually only 8, or 7, 5, 4 or 3, usually united below into an open tube; G̲ (5—2), usually (2), antero-posterior; ovary 2-loc. with 1 anatropous pendulous ovule in each loc. (rarely 1-loc. with ∞ ovules). Capsule, nut or drupe. Endosperm or not. The floral mechanism, like the structure, resembles that found in many Leguminosae. *Chief genera:* Polygala, Securidaca, Xanthophyllum. Placed in Polygalinae by Benth.-Hooker, in Aesculinae by Warming. [See Krameria.]



Floral diagram of *Polygala myrtifolia* (after Eichler); the gland *d* as in *P. Chamaebuxus.* Petals and bracts black; the missing petals represented by dotted lines, the missing sta. by *.

Polygaleae (Benth.-Hooker) = Polygalaceae.

Polygalinae (Benth.-Hooker). The 3rd cohort of Polypetalae (p. 132).

Polygonaceae. Dicotyledons (Archichl. Polygonales). 30 gen. with 750 sp. chiefly N. temp.; a few trop., arctic, and S. hemisph. Most are herbs whose leaves (exc. *Eriogoneae*) possess a peculiar sheathing stipule or *ochrea* (ocrea) clasping the stem above the leaf-base. This forms a characteristic feature of the order. The infl. is primarily racemose, but the partial infls. are usually cymose. [See Eriogonum.] The flrs. are ☿, regular, cyclic or acyclic. The former have usually the formula P 3 + 3, homochlamydeous; A 3 + 3, G̲ (3); but many vary from this type. Oxyria is 2-merous; others, *e.g.* Eriogonum, Rheum, have 'dédoublement' of the outer sta. The acyclic flrs. have P 5, arranged according to the 2/5 phyllotaxy (e.g. Polygonum), A 5—8, G (3). Ovary 1-loc. with 1 erect orthotropous ovule and 3 styles. The flrs. are pollinated by wind or by insects. The fruit is almost always a triangular nut, with smooth exterior. The seed contains an excentric curved or straight embryo surrounded by mealy endosperm, sometimes ruminate. The fruits are usually wind-distributed; the commonest type of mechanism is that the persistent perianth forms a membraneous wing round the fruit. Other fruits are provided with hooks for carriage by animals. See individual genera or Dammer in *Nat. Pfl.*

Classification and chief genera (after Dammer):

A. Flower cyclic, endosperm not ruminate.

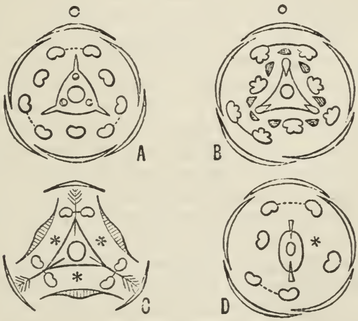
I. *RUMICOIDEAE.*
1. *Eriogoneae* (no ochrea): Chorizanthe, Eriogonum.
2. *Rumiceae* (ochreate): Rumex, Rheum, Oxyria.

B. Acyclic (except a few Coccoloboideae)

II. *POLYGONOIDEAE* (endosperm not ruminate).
3. *Atraphaxideae* (shrubs): Calligonum.
4. *Polygoneae* (herbs): Polygonum, Fagopyrum.

III. *COCCOLOBOIDEAE* (ruminate).
5. *Coccolobeae* (usually ☿): Muehlenbeckia, Coccoloba.
6. *Triplarideae* (usually diœcious): Triplaris.

[Placed in Curvembryae by Benth.-Hooker, in Polygoniflorae by Warming.]



Floral diagrams (after Eichler). *A*, Rheum; *B*, *Polygonum tataricum*; C. Rumex; *D*. *Polygonum lapathifolium*. Bracts and bracteoles are omitted, and in *C* and *D* the axis also. Glands in *B* shaded. The asterisks represent missing sta.

Polygonales. The 9th cohort of Archichlamydeae (p. 128).

Polygonatum (Tourn.) Adans. Liliaceae (VII). 25 sp. N. temp.; 3 in Brit. (Solomon's seal). There is a sympodial fleshy rhizome, upon which the annual shoots leave curious seal-like marks when they die away. Infl. unilateral; flr. homogamous, bee-pollinated.

Polygoniflorae (Warming). The 5th cohort of Choripetalae (p. 137).

Polygonum (Tourn.) Linn. Polygonaceae (II. 4). 150 sp. universal, but esp. temp. (11 in Brit., knot-grass, bistort, &c.). In habit the genus varies much, though all are herbaceous. Some are xerophytes, some water plants (e.g. our common *P. amphibium* L., which may however be found almost as often on land where its leaves have not the stalks of the water form). The flrs. are in spikes and panicles (the partial infl. is cymose). Flrs. ☿, acyclic, usually with a coloured 5-leaved perianth and about 8 sta. Honey is secreted at the base of the sta., and the flrs. are visited by insects, but in very varying degree (see the interesting series of sp. described by Müller in *Fert. of Flrs.* p. 509). Cleistogamic flrs. are found under the ochrea in *P. aviculare* L. &c., and this sp. also is said to possess subterranean cleistogamic flrs. In *P. viviparum* L. (an alpine Brit. sp.) many of the flrs. are replaced by bulbils in the lower part of the infl. (cf. Lilium, Allium). [For *P. Fagopyrum* L. see Fagopyrum.]

Polypetalae (Benth.-Hooker). A division of Dicotyledons (p. 132).

Polypodiaceae. Filicineae Leptosporangiatae (Homosporous). 55 gen. with 3000 sp., cosmop. Mostly herbaceous perennials with a creeping rhizome or erect root-stock; many are epiphytic. Leaves usually large and pinnate, with sori on the lower sides. Each sorus consists usually of a large number of stalked sporangia, each with a vertical incomplete annulus and dehiscing transversely. An indusium may or may not be present. *Chief genera:* Acrostichum, Davallia, Pteris, Polypodium, Platycerium, Adiantum, Asplenium, Aspidium, Nephrodium.

Polypodium Linn. Polypodiaceae. 400 sp. cosmop. Several occur in Brit., viz. *P. alpestre* Hoppe, *P. Dryopteris* L. (oak-fern), *P. Phegopteris* L. (beech-fern), *P. vulgare* L. (common polypody). They have circular naked sori. Many trop. sp. are epiphytic and show interesting features. The rhizomes creep over the supporting tree, and humus is collected in niches formed between it and the leaves. An ordinary P. leaf with its bare petiole below would be useless, but these sp. have leaves whose blade reaches down to the base. *P. Heracleum* Kze. is a good example. *P. quercifolium* L. and others are still more interesting, as they exhibit two kinds of leaves, the one of the ordinary branched type, projecting out from the support and serving for assimilation and spore-bearing, the others small leaves like those of the oak, close to the rhizome, forming humus-collecting niches (cf. Platycerium, and see Goebel *Pflanzenbiol. Sch.* I. p. 216).

Polypogon Desf. Gramineae (VIII). 10 sp. warm temp. and trop.; 2 in Brit. rare (beard-grass).

Polystachya Hook. Orchidaceae (9). 40 sp. trop., esp. Afr.

Pomaceae (Warming). = Rosaceae (sub-order II).

Pomaderris Labill. Rhamnaceae. 20 sp. Austr., N. Z.

Pontederia Linn. Pontederiaceae. 2 sp. Am. Flrs. trimorphic, heterostyled (cf. Lythrum). *P. crassipes* Mart. = *Eichhornia crassipes.*

Pontederiaceae. Monocotyledons (Farinosae). 6 gen. with 21 sp. trop. Water plants (p. 158), floating or rooted, of sympodial structure, the successive axes ending in infls. (sympodial cymose pseudoracemes). Often, *e.g.* in Eichhornia, the axillary shoot is adnate to the main shoot from which it springs (p. 42). Sometimes extra branches are formed, and the axis of the infl. is often pushed to one side so that it appears to spring from a leaf-sheath. Fls. zygomorphic. P (3 + 3), persistent; A 3 + 3, epiphyllous, G (3), 3-loc. with ∞ anatropous ovules, or 1-loc. with 1 ovule; style long, stigma entire or slightly lobed. Capsule or nut. Embryo central in the seed, scarcely, or not, shorter than the rich mealy endosperm. *Chief genera:* Eichhornia, Pontederia. Placed in Coronarieae by Benth.-Hooker, in Liliiflorae by Warming.

Populus Linn. Salicaceae. 18 sp. N. temp. *P. alba* L. (white poplar) and *P. tremula* L. (aspen) in Brit. Like Salix in most features, but the flrs. are wind-pollinated and have no honey; correlated with this is the fact that they have usually more sta. than those of Salix. The wood of *P. alba* is useful, and also that of *P. nigra* L. (black poplar) with its variety *pyramidalis* Spach (*P. fastigiata* Desf.), the Lombardy poplar, often grown in parks &c., *P. canadensis* Michx. (cotton-wood tree, N. Am.) and others. *P. balsamifera* L. is the balsam poplar, and yields a resin known as Tacamahac (see Calophyllum).

Porana Burm. f. Convolvulaceae (I. 4). 10 sp. Indo-mal., Austr.

Porlieria Ruiz et Pav. Zygophyllaceae. 3 sp. Mexico and Andes. The leaflets of *P. hygrometrica* Ruiz et Pav. spread out horizontally at night, but during the day are folded up in pairs against one another, avoiding excessive transpiration.

Porrum (Tourn.) Linn. = Allium Tourn.

Portulaca Linn. Portulacaceae. 20 sp. trop. and subtrop. The flr. has a semi-inferior ovary and 4—∞ sta. It is homogamous with self-fertilisation on withering, and remains closed in bad weather. The sta. of *P. oleracea* L. are sensitive to contact and move toward the side touched.

Portulacaceae. Dicotyledons (Archichl. Centrospermae). 17 gen. with 144 sp., cosmop., but esp. Am. Most are annual herbs, often with fleshy leaves, and with stipules (sometimes represented by axillary bundles of hairs). Flrs. usually in cymes (often dichasia with tendency to cincinni), regular, ☿. K 2, the lower sepal (usually anterior) overlapping the upper (the two are often regarded as bracteoles); C 5; A 5 + 5, or 5 opp. the petals, or some other number; G (2—8) usually (3), superior exc. in Portulaca, 1-loc. with several stigmas and 2—∞ campylotropous ovules on a central basal placenta. The flrs. secrete honey and are mostly insect-pollinated. Fruit a capsule with albuminous seeds; that of Claytonia and Montia is explosive; embryo more or less curved round the perisperm. *Chief genera:* Calandrinia, Spraguea, Claytonia, Montia, Portulaca, Lewisia. Placed in Caryophyllinae by Benth.-Hooker, in Curvembryae by Warming.

Portulaceae (Benth.-Hooker) = Portulacaceae.

Portulacaria Jacq. Portulacaceae. 2 sp. S. Afr.

Posidonia Kon. Potamogetonaceae. 2 sp. Austr., Medit.

Posoqueria Aubl. Rubiaceae (I. 8). 5 sp. S. Am.

Potamogeton (Tourn.) Linn. Potamogetonaceae. 50 sp. cosmop. 11 or more (cf. Rubus) in Brit. (pond-weed). Water plants with creeping sympodial rhizomes and erect leafy branches; leaves all submerged or some floating. A whole series of types occurs, beginning with the floating sp. and ending with the narrow-leafed submerged ones (see p. 160). There can be no doubt of the origin of the P. from land plants, and Schenck looks upon *P. natans* L. as the sp. least modified to suit a water existence, *i.e.* the nearest to the ancestral type. The upper leaves are ovate, leathery, and float on the water; the lower are submerged, and sometimes reduced to a linear form. Then come such sp. as *P. heterophyllus* Schreb. where the submerged leaves are all narrow. Next *P. lucens* L., *P. crispus* L., &c. with all the leaves lanceolate and submerged. Then in *P. obtusifolius* Mert. et Koch, *P. pusillus* L., &c., the leaves are narrow and of a long ribbon shape. *P. trichoides* Cham. et Schlecht. represents the most highly modified type of all. [All the above are Brit. sp.; they are best studied at first in a herbarium, for P. is as variable a genus as Rubus or Hieracium, and the sp. are exceedingly difficult to determine. The fact is that probably the genus is still in a condition of rapid evolution of which the sp. above mentioned represent various stages.] Interesting phenomena connected with the above are to be seen in the germination of the seeds. The internal anatomy also shows interesting features in the series of types mentioned.

Hibernation occurs in different ways; some sp. remain green all winter; *P. natans*, &c. die down and leave only the rhizome; *P. pectinatus* L. forms peculiar tubers on special branches (Schenk, *Wassergewächse*, p. 86); *P. crispus* and others form winter buds with broad leaves (not closely packed as in Utricularia &c., but wavy, like holly leaves); *P. obtusifolius* forms winter buds of the ordinary kind. The flrs. are of simple structure, arranged in spikes which project above the water. Each has 4 sta. in two whorls, and 4 cpls. From the connective of each sessile anther there grows out a cup-shaped expansion simulating a perianth leaf. The flr. is protogynous and wind-fertilised. The outer layer of the pericarp contains air, so that the fruit, which is an achene, floats on the water and may thus be carried to a distance, finally sinking when the air escapes. [For further details see p. 158 and Literature.]

Potamogetonaceae. Monocotyledons (Helobieae). 9 gen. with 70 sp. cosmop. All are water plants, several of them being marine. There is in most a creeping stem or rhizome, mono- or sym-podial, attached to the soil by adventitious roots, and sending off erect branches upwards into the water. These usually have ribbon leaves, submerged (exceptions occur in Potamogeton), arranged in ½ phyllotaxy. The base is sheathing, and within the sheath are the small scales (*squamulae intravaginales*) which occur in most of the orders of Helobieae. The infl. is a spike or cyme, or the flrs. solitary. The flrs. possess no true perianth (exc. Zannichellia ♀), but Potamogeton shows leaf-like outgrowths from the sta. which perform the perianth functions; similar structures occur in Zostera and Ruppia. In several genera it is not easy to decide what is to be regarded as the flr. (see Zostera).

Flr. ☿ or unisex., regular, 1—4-merous. Cpls. free or only 1. Ovules 1 in each cpl., pendulous, orthotropous. Fruit one-seeded. No endosperm. Embryo with well developed hypocotyl. For details see genera.

Chief genera:

A. Flrs. in spikes:

1. salt water: Zostera, Phyllospadix, Posidonia, Ruppia.
2. fresh or brackish: Potamogeton.

B. Flrs. in cymes or solitary: Cymodocea, Zannichellia.

[Benth.-Hooker unite P. to Aponogetonaceae, Juncaginaceae and Naiadaceae, and place the whole order (Naiadeae) in Apocarpae. Warming places it in Helobieae.]

Potentilla Linn. (incl. *Comarum* Linn., *Sibbaldia* Linn., *Tormentilla* Linn.). Rosaceae (III. 6 b). 200 sp. chiefly N. temp. and arctic, a few S. temp. and Andes; 9 in Brit., incl. *P. Anserina* L. (silverweed), *P. reptans* L. (cinquefoil), *P. Comarum* Nestl., *P. Tormentilla* Neck. (tormentil), &c. Herbs, usually with creeping stems which root at the nodes and thus multiply the plant vegetatively. There is a well-marked *epicalyx* of small green leaves outside and alt. with the sepals. These are the stipules of the sepals united in pairs; often one or more of them may be seen with two lobes or even completely divided. Flrs. homogamous, fly-visited; honey is secreted by a ring-shaped nectary within the sta.

Poterium Linn. (incl. *Sanguisorba* Rupp. ex Linn.). Rosaceae (III. 9). 30 sp. N. temp.; 2 in Brit. (burnet). *P. Sanguisorba* L. is anemophilous with long pendulous sta. (cf. Thalictrum, Artemisia); it is also gynomonœcious, the ♀ flrs. at the top of the spike opening first, and afterwards the ☿ flrs. below. *P.* (*S.*) *officinale* A. Gray shows more trace of its entomophilous ancestry; the sta. are rigid and of a reddish colour, the stigma is less branched, and there is a nectary round the style (cf. Rumex and Rheum).

Pothos Linn. Araceae (1). 30 sp. trop. As., Madagascar. Monopodial (see order). Stem climbing, with adventitious roots. The buds break through the leaf-axils, so that the branching seems infra-axillary. Flr. ☿. P 3 + 3.

Pourthiaea Dcne. Rosaceae (II. 4). 5 sp. E. As.

Pouzolzia Gaudich. Urticaceae (3). 35 sp. Old World trop. The root of *P. tuberosa* Wight is eaten in India.

Prangos Lindl. Umbelliferae (6). 30 sp. Medit., Cent. As.

Prasium Linn. Labiatae (III). 1 sp. Medit.

Pratia Gaudich. Campanulaceae (III). 16 sp. S. Am., Austr., trop. As.

Premna Linn. Verbenaceae (IV). 40 sp. trop. and subtrop. (exc. Am.).

Prenanthes Vaill. ex Linn. Compositae (XIII). 27 sp. N. temp. and Afr.

Priestleya DC. Leguminosae (III. 3). 15 sp. S. Afr.

Primula Linn. Primulaceae (1). 146 sp., N. hemisph. chiefly in hilly districts. A few occur elsewhere, *e.g. P. farinosa* L., var. *magellanica* Hook. at the Str. of Magelhaen. The rhizome is a sympodium, each joint terminating in an infl. In some sp. this consists of successive whorls of flrs. arranged up a long stalk, *e.g. P. japonica* A. Gray. The genus has been monographed by Pax (see *Nat. Pfl.*). A few of the more important sp. are: *P. sinensis* Sabine, the Chinese primrose, *P. elatior* Hill, the oxlip (Brit.), *P. vulgaris* Huds. (*P. acaulis* Hill), the primrose (Brit.), *P. veris* Lehm. (*P. officinalis* Jacq.), the cowslip (Brit.), *P. farinosa* L. (Brit.), *P. japonica* A. Gray, a most beautiful plant, not as often cultivated as it deserves to be, *P. Auricula* L., the auricula with its many forms. A great many hybrids also occur, and garden varieties. An interesting one is the double crowned cowslip, in which the calyx has become petaloid, so that the flr. looks as if it had two corollas, one within the other.

The flrs. of P. are dimorphic, heterostyled. On one plant are found long-styled flrs., with sta. halfway up the tube of the corolla and the stigma at its mouth; on another plant are short-styled flrs., with stigma halfway up and anthers at the mouth. The depth and narrowness of the tube render the flr. adapted to bees or butterflies, and these will tend to carry pollen from long sta. to long style or from short sta. to short style. These 'legitimate' pollinations (see Lythrum and p. 95) which are at the same time crossings, are the only ones which produce a full complement of fertile seed.

The flower stalks in the umbellate forms, *e.g.* cowslip, stand close and erect till the flrs. open, then they spread out, and close up again as the fruit ripens; thus the capsule is held erect and the seeds must be shaken out.

Primulaceae. Dicotyledons (Sympet. Primulales). 28 gen. with 350 sp. cosmop., but esp. N. temp. There are 9 Brit. genera, representing all but one of the suborders. They are herbaceous plants, commonly perennial, with rhizomes or tubers; leaves opp. or alt., exstip. The flrs. are often borne on scapes, which when more than one flowered are terminal; they are usually actinomorphic, ☿, often heterostyled, and 5-merous, without bracteoles, the odd (4th) sepal posterior. K (5) persistent; C (5), regular (exc. Coris), or 5, or 0 (Glaux); A 5, epipetalous and opposite the petals; occasionally 5 staminodes alternate with the petals; anthers introrse. The presence of the staminodes here as in Myrsinaceae, explains the antepetalous position of the sta. as due

Floral diagram of *Primula acaulis* (after Eichler).

to the abortion of the originally outer whorl. Much discussion took place on this subject in former times, especially after Pfeffer's discovery of the peculiar development of the corolla from the backs of the sta. (see Eichler, *Blüthendiag.* or Asa Gray, *Struct. Bot.* p. 197). Ovary superior or half-inferior (Samolus), syncarpous with free central placenta, typically of 5 cpls., but this is not easily proved, as no partitions (cf. Caryophyllaceae) are found in the ovary and the style and stigma are simple. The capsule splits into 5 valves, and monstrous flrs. with 5 leaves in place of the ovary occur; hence we may perhaps assume 5 cpls. Ovules ∞, spirally or in whorls on the placenta, semi-anatropous. The morphology of the free-central placenta has also been a subject of dispute (see Pax in *Nat. Pfl.*, or Eichler, *Blüthendiag.*).

A great number of the P. have heterostyled flowers (Primula, Hottonia, Glaux, Androsace, &c., *q.v.* for details).

The fruit is a capsule, dehiscing in various ways, but usually by teeth at the tip, one opposite to each sepal. Seeds few or many; embryo small, in fleshy endosperm.

Classification and chief genera (after Pax):

A. Flowers regular. Calyx not spiny.
  a. Limb of corolla never bent back on tube.
    α. Corolla aestivation quincuncial.
      I. *Primuleae* (ovary sup.): Primula, Androsace, Soldanella, Hottonia.
      II. *Samoleae* (ovary semi-inf.): Samolus (only genus).
    β. Aestivation convolute.
      III. *Lysimachieae:* Lysimachia, Steironema, Trientalis, Glaux, Anagallis, Centunculus.
  b. Limb of corolla bent back.
      IV. *Cyclamineae:* Cyclamen, Dodecatheon (only genera).
B. Flowers medially zygomorphic. Calyx spiny.
      V. *Corideae:* Coris (only genus).

[Placed in Primulales by Benth.-Hooker, in Primulinae by Warming.]

Primulales. The 2nd cohort (Engler) of Sympetalae (p. 130). The 5th cohort (Benth.-Hooker) of Gamopetalae (p. 134).

Primulinae (Warming). The 3rd cohort of Sympetalae (p. 137).

Principes. The 4th cohort of Monocotyledons (p. 126).

Pringlea Anders. Cruciferae (I. 1). *P. antiscorbutica* R. Br., the Kerguelen cabbage, is the only sp. It has the habit of a cabbage, with the flrs. borne on lateral axes, and is a valuable remedy against scurvy on account of its essential oil. It grows only "on the tempestuous shores of Kerguelen's I., where winged insects cannot exist, because at every flight they run the risk of being drowned. Under these circumstances the plant has become modified for fertilisation by the wind, acquiring exserted anthers and long filiform stigmatic papillae. It still retains traces of its descent from entomophilous ancestors; for while on the great part of the island it is devoid of petals, it occurs abundantly in shaded places with petals" (Müller).

Prinos Gronov. ex Linn. = Ilex Tourn.

Prionium E. Mey. Juncaceae. 1 sp. Cape Col., *P. Palmita* E. Mey. (*P. serratum* Buchen.), the Palmiet, a shrubby aloe-like plant with a stem 1—2 metres high, covered with the fibrous remains of old leaves. It grows on the edges of streams, sometimes almost blocking them up. Vegetative propagation takes place by the formation of runners. Adventitious roots are formed between the leaves. [See Buchenau in *Bibliotheca Botanica*, No. 27.]

Pritchardia Seem. et H. Wendl. (excl. *Washingtonia* H. Wendl.). Palmae (I. 2). 5 sp. west U.S., Sandwich Is.

Priva Adans. Verbenaceae (II). 10 sp. trop. and subtrop. The leaves of *P. echinata* Juss. are used in Am. as tea. The tubers of *P. laevis* Juss. are edible.

Proboscidea Schmid. = Martynia Houst.

Procris Comm. ex Juss. Urticaceae (2). 5 sp. trop.

Prosopis. Leguminosae (I. 4). 25 sp. trop. and subtrop. Some are xerophytes, without leaves. Many are thorny, the thorns being epidermal, or metamorphosed branches or stipules. *P. juliflora* DC. is the mezquit tree. *P. alba* Griseb. has sweet succulent pods (Algaroba blanca), used as food.

Prostanthera Labill. Labiatae (II). 40 sp. Austr.

Protea Linn. Proteaceae (I). 60 sp. Cape Colony. Flrs. in showy heads, often with coloured bracts.

Proteaceae. Dicotyledons (Archichl. Proteales). 50 gen. with 960 sp. "which have a very characteristic distribution; there are in Austr. 591, trop. E. As. 25, New Caled. 27, N. Z. 2, Chili 7, trop. S. Am. 36, south-west Cape Col. 262, Madag. 2, Mts. of trop. Afr. 5" (Engler). A consideration of the above figures will show that the great majority of the order lives in regions where there is annually a long dry season. Correlated with this is the fact that these plants are mostly of xerophytic habit (p. 163). They are nearly all shrubs and trees with entire or much-divided exstip. leaves, which have commonly a thick cuticle and often a covering of hairs further to check transpiration. They also exhibit in their internal anatomy various xerophytic characters (see *Nat. Pfl.*). The flrs. are borne in racemes, spikes, heads &c., and are often very showy; it is noteworthy that many have their pollen freely exposed, though they are not wind-fertilised —another peculiarity connected with their life in a dry climate (compare the Acacias of Australia).

The flrs. are usually ☿, often zygomorphic. Perianth (4), corolline, valvate; the leaves commonly bent or rolled back when open; sta. 4, inserted on the tepals, and usually with only the anthers free; G 1, ovules many or few or one, pendulous or not, the micropyle facing the base of the ovary. The style is terminal, long, often bent inwards. Fruit a follicle, capsule, drupe or nut. Seed exalbuminous. The ovary is sometimes borne on a gynophore and at its base are commonly nectarial outgrowths. The flrs. are protandrous and adapted to insect-fertilisation.

Classification and chief genera (see discussion in *Nat. Pfl.*).

I. *PERSOONIOIDEAE* (flrs. single in axils of bracts; ovules seldom few or 2; drupe or nut, one seeded): Persoonia, Protea, Leucadendron.

II. *GREVILLOIDEAE* (flrs. in pairs; ovules several or 2; fruit usually dehiscent and many seeded): Grevillea, Hakea, Banksia.

[Placed in Daphnales by Benth.-Hooker, in Thymelaeinae by Warming.]

Proteales. The 6th cohort of Archichlamydeae (p. 127).

Protium Burm. f. Burseraceae. 50 sp. trop. Am. Some yield resins.

Prunella Linn. (*Brunella* Tourn.) Labiatae (VI. 4). *P. vulgaris* L. (self-heal) is cosmop. (incl. Brit.), the other 5 sp. Medit. Eur. The fruiting calyx is closed and points upwards in dry air, but opens and stands horizontally in damp.

Prunus (Tourn.) Linn. (incl. *Amygdalus* Tourn., *Cerasus* Tourn.). Rosaceae (V. 12). 75 sp. N. temp.; a few trop. *P. insititia* L. (bullace), *P. spinosa* L. (sloe or blackthorn), *P. Avium* L. (gean), *P. Padus* L. (bird-cherry), in Brit. The flr.-buds are laid down in August or September of the preceding year. There is 1 cpl., which gives rise to a drupe, while the hollow receptacle usually falls away. Many sp. are cultivated for their fruit, *e.g. P. Armeniaca* L. (apricot), *P. domestica* L. (plum, prune), *P. Amygdalus* Stokes (almond), *P. Persica* Stokes (peach, with its smooth-fruited variety the nectarine), *P. Cerasus* L. (cherry), &c. *P. Laurocerasus* L. is the cherry laurel; it has extra-floral nectaries (p. 114) on the backs of the leaves, showing as brownish patches against the midribs. The spines of some sp. are axillary, as in Crataegus.

Psamma Beauv. = Ammophila Host.

Pseuderanthemum Radlkf. Acanthaceae (IV. B). 60 sp. trop.

Pseudolarix Gord. Coniferae (I. 1 b). 1 sp. *P. Kaempferi* Gord., the golden pine, China. Like Larix, but distinguished chiefly by the deciduous fruit-scales.

Pseudotsuga Carr. = Tsuga Carr.

Psidium Linn. Myrtaceae (I). 100 sp. trop. Am. Many yield edible fruit, *e.g. P. Guajava* L., the guava.

Psilotaceae. Lycopodinae (Homosporous). Two genera (Psilotum, Tmesipteris) with 3 sp. trop. and subtrop. The mature sporophyte has no roots, their functions being performed by the branched rhizomes. The aerial branches bear only scale-leaves in Psilotum. The sporangia are 2- or 3-loc., borne on small two-lobed sporophylls. "There has been much disagreement as to the morphological nature of the sporangiophores of the Psilotaceae. The two chief views are the following: (1) that the whole sporangiophore is a single foliar member; (2) that it is a reduced axis bearing a terminal synangium and two leaves. The recent very careful researches of Bower upon the origin of the sporangiophore and synangium confirm the former view" (Campbell; see also Bower in *Phil. Trans.* CLXXXV, 1894, p. 473).

"The fully-developed synangium (2-loc. in Tmesipteris, 3-loc. in Psilotum) has the outer walls of the loculi composed of a superficial layer of large cells, beneath which are several layers of smaller ones. The cells composing the septa are narrow tabular ones; occasionally the septum is partially absent.... Bower regards the whole synangium as homologous with the single sporangium of Lycopodium" (Campbell). The prothallus has not been seen.

Psilotum Sw. Psilotaceae. 2 sp. trop. They are probably saprophytic in their habit, and have neither roots nor green leaves, but only green stems. See order for details of sporangia &c. Vegetative reproduction is common, small gemmae being formed upon the rhizomes. At first no structural differentiation is visible in these, but apical cells are formed later.

Psoralea Linn. Leguminosae (III. 6). 100 sp. Afr., As., Austr. *P. esculenta* Pursh (N. Am.) is the prairie turnip, with an edible tuberous root.

Psychotria Linn. (excl. *Mapourea* Aubl.). Rubiaceae (II. 15). 360 sp. trop. Some are heterostyled. Many have the infl.-axis brightly coloured. See Cephaelis. [For *P. Ipecacuanha* Stokes see Uragoga.]

Ptelea Linn. Rutaceae (IX). 7 sp. N. Am. *P. trifoliata* L. is often grown in parks (shrubby trefoil). Flrs. monœcious. Fruit winged (cf. Ulmus).

Pteridophyta. Vascular Cryptogams, one of the four chief divisions of the Vegetable Kingdom. They have a well marked alternation of generations, the oophyte (gametophyte or sexual generation) being insignificant in size compared to the sporophyte (asexual generation), but still capable of independent growth. The life history of a typical Pteridophyte may be shown diagrammatically as follows, taking the fern as an example:

$$\begin{array}{ccccccc} \text{Fern-plant} & \rightarrow & \text{sporophylls} & \rightarrow & \text{sporangia} & \rightarrow & \text{spores} \\ \uparrow & & & & & & \downarrow \\ \text{fertilised ovum} & \leftarrow & \left\{\begin{array}{l}\text{spermatozoid}\\ \text{ovum}\end{array}\right. & \begin{array}{c}\leftarrow\\ \leftarrow\end{array} & \left.\begin{array}{l}\text{antheridia}\\ \text{archegonia}\end{array}\right\} & \leftarrow & \text{prothallus.}\end{array}$$

The 'plant' or asexual generation alternates with the prothallus or sexual generation. In many P. there are male and female prothalli. The prothallus corresponds to the 'plant' in a moss or liverwort, whilst the sporogonium of these latter is the equivalent of the 'plant' in a fern or lycopod.

The plant itself takes various forms in the different groups. Except in the tree ferns and in fossil forms it does not attain any great size. There is an erect stem in many ferns &c.; others have creeping stems (e.g. Lycopodium and Selaginella), rhizomes (many Ferns), or floating stems (Hydropterideae). The leaves are simple, except in many ferns. There is no primary tap-root, but roots are formed as required from the stem or leaves. Internally there are well marked vascular bundles in both stem and leaf, and many of the anatomical features of Phanerogams may be found here also.

The sporangia arise upon the leaves, either on the ordinary foliage as in most ferns, or on specially differentiated leaves as in Osmunda, Equisetum, Lycopodineae, Hydropterideae, &c. They may be solitary or in groups (*sori*); in the latter case they are often protected by a special outgrowth of the leaf, the *indusium*. The spores are formed by a complicated process from a single cell or row or layer of cells—the *archesporium*—inside the sporangium: each has a thick waterproof outside wall. The spores may be of one kind only, in which case the plant is termed *homo-* or *iso-sporous*, or of two kinds (*heterosporous*). In this case the smaller spore is termed the *microspore*, the larger the *mega-* or *macro-spore*; the former gives rise to a male prothallus, the latter to a female.

Falling upon the soil (or into the water, in the case of the Hydropterideae) the spores germinate under suitable conditions, giving rise to the *sexual* plants or *prothalli*. The prothallus is a small body without distinction into stem and leaf; it absorbs materials from the soil (usually by rhizoids) and, being green, assimilates in the ordinary way. It bears the sexual organs—*antheridia* (male) and *archegonia* (female). In the homosporous forms these are both found on the same prothallus, except in Equisetum, where, though the spores are absolutely similar so far as we can tell, there are separate male and female prothalli, as in the heterosporous forms. In the antheridia are developed the motile male cells or *antherozoids* (often called *spermatozoids* as they are equivalent to the spermatozoa of animals). Fertilisation takes place by aid of water. The mucilage contained in the neck of the archegonium is attractive to the spermatozoids (p. 56), which swim up the neck of the archegonium. One of them finally fuses with the *ovum* or female cell at the base of the archegonium, and the fertilised ovum (*zygote*) then developes into a new 'plant' or asexual generation, being nourished by the prothallus until it can assimilate for itself.

Classification:

I. *Filicineae:* Mostly homosporous, with monœcious prothalli (Hydropterideae are heterosporous, with diœcious prothalli). Stem with few or no branches; leaves usually large and branched. Sporangia numerous, on ordinary or on metamorphosed leaves, commonly collected into sori. See F. for further classification.

II. *Equisetineae:* Homosporous (some fossil forms are heterosporous), with diœcious prothalli. Stem much branched with jointed internodes and small sheathing whorls of leaves (not green). Sporangia on peltate sporangiophores, forming a terminal spike.

[III. *Sphenophylleae:* fossil plants only.]

IV. *Lycopodineae:* Homosporous or heterosporous; in the latter case the female prothallus remains enclosed in the spore till fertilisation. Stem simple or branched; leaves many, small, entire. Sporangia singly on upper side of leaf-bases, or in their axils, or on a sporangiophore.

Pteridium Gleditsch = Pteris Linn.

Pteris Linn. Polypodiaceae. 100 sp. cosmop. *P. aquilina* L. the bracken, is best known, and is common in Brit. It has a creeping rhizome, bearing two ranks of leaves. At the base of the leaf is a nectary whose use is unknown; ants may be seen visiting it. The sori are confluent along the leaf-margin which is curved over them. The bracken is sometimes placed in a genus Pteridium distinct from all the other sp. on account of its having a true indusium on the inner side of the sorus, in addition to the 'false' indusium formed by the curving over of the leaf blade. Adventitious buds appear on the back of the leaf stalk, near the base (cf. Aspidium). Apogamy occurs in *P. cretica* L. (see Filicineae Leptosporangiatae).

Pterocarpus Linn. Leguminosae (III. 8). 20 sp. trop. Several sp., esp. *P. Marsupium* Roxb., furnish Kino, an astringent resin. *P. santalinus* L. f. yields red sandal-wood. The fruit is winged.

Pterocarya Kunth. Juglandaceae. 4 sp. N. temp.

Pterocephalus Vaill. = Scabiosa Tourn.

Pteronia Linn. Compositae (III). 52 sp. S. Afr.

Pterostylis R. Br. Orchidaceae (4). 40 sp. Austr., N. Z., New Caled. The median sepal, with the petals, forms a hood over the rest of the flr. The flap of the labellum hangs out below and is irritable. If an insect land on it, it instantly moves up and imprisons the visitor against the column; the only mode of escape is by squeezing past the stigma and anther. After half-an-hour the lip goes down again and is ready for another capture (Darwin, *Orchids*, p. 86).

Ptychosperma Labill. Palmae (IV. 6). 15 sp. Indo-mal. Flrs. in threes, 2 ♂ and 1 ♀. *P.* (*Seaforthia*) *elegans* Blume is a favourite ornamental palm.

Pugionium Gaertn. Cruciferae (IV. 18). 2 sp. Mongolia.

Pulicaria Gaertn. Compositae (IV). 30 sp. Eur., As., Afr. *P. dysenterica* Gaertn. (*Inula dysenterica* L.) in Brit. (flea-bane).

Pulmonaria (Tourn.) Linn. Boraginaceae (IV. 3). 10 sp. Eur. *P.*

officinalis L. (lung-wort, formerly officinal) and *P. angustifolia* L. in Brit. Both have dimorphic heterostyled flrs. which change from red to blue as they grow older (see order).

Pulsatilla (Tourn.) Linn. = Anemone Tourn.

Pultenaea Sm. Leguminosae (III. 2). 76 sp. Austr.

Punica (Tourn.) Linn. The only genus of Punicaceae. 2 sp., one in Socotra, the other, *P. Granatum* L., the pomegranate, from the Balkans to the Himalayas, and cultivated in most trop. lands. The young twigs of the tree have four wings, composed simply of epidermis and cortical parenchyma; these are early thrown off. The flr. is ☿, regular, perigynous. K 5—8, valvate; C 5—8, imbricate. Sta. ∞. Ovary adnate to receptacle. The mature ovary has a peculiar structure, due to a development like that in Mesembryanthemum. Two whorls of cpls. with basal placentae are laid down, and then a peripheral growth tilts them up from ‖ • ‖ to = . = so that two layers of loculi are formed and the placentation appears to be parietal. Ovules ∞, anatropous. The arrangement is also seen in the fruit, commonly termed a berry, but not strictly so. The pericarp (axial in part) is leathery, and the fleshy inner part round the seeds is really the outer layers of the seed coats.

Punicaceae. Dicotyledons (Archichl. Myrtiflorae). Only genus Punica (q.v.). Placed in Lythraceae by Benth.-Hooker and in Myrtaceae by Warming.

Pupalia Juss. Amarantaceae (2). 5 sp. Afr., As.

Purshia DC. Rosaceae (III. 7). 1 sp. West U.S.

Pusaetha Linn. = Entada Adans.

Puschkinia Adams. Liliaceae (V). 2 sp. W. As.

Pycnanthemum Michx. Labiatae (VI. 11). 13 sp. N. Am.

Pyrethrum Hall. = Chrysanthemum Tourn.

Pyrola (Tourn.) Linn. (incl. *Moneses* Salisb.). Pyrolaceae. 15 sp. N. Temp. (5 Brit. wintergreen). Evergreens with creeping stocks. *P.* (*Moneses*) *uniflora* L. has adventitious buds on the roots, and a solitary terminal flower. *P. minor* L. is the most frequent in Brit. The flrs. are in racemes, pendulous, without discs. There is no honey; the stigma projects beyond the anthers, but pollen may at last fall upon it from them. *P. rotundifolia* L. is similar. The seeds of P. are very light and are distributed by wind. Many sp. prefer shady places.

Pyrolaceae. Dicotyledons (Sympet. Ericales). 10 gen. with 30 sp., cold N. temp. and arctic. The two Brit. genera represent the two types of habit found in the order—evergreen plants with sympodial growth from rhizomes (Pyrola), and saprophytes (Monotropa). The infl. is terminal; it may be a true raceme (Pyrola), or a cyme, leafless or with scaly bracts. Flr. ☿ actinomorphic. K 4—5; C (4—5) or 4—5; A 8—10, obdiplostemonous; $\underline{G}$ (4—5). The petals and sta. are often at the edge of a nectariferous disc. Anthers introrse, opening by apical pores or transverse valves; pollen simple or in tetrads.

Cpls. opp. petals; ovary imperfectly 4—5-loc. Style simple. Ovules minute, ∞, anatropous, on thick fleshy placentae. Fruit a capsule. Seeds ∞, small, in loose testa. Embryo of few cells, without differentiation of cotyledons. *Chief genera:* Pyrola, Chimaphila, Monotropa, Sarcodes. Benth.-Hooker united Pyrola and the similar green-leaved forms to Ericaceae, making an order Monotropeae for the Saprophytes; they place both in Ericales; they are placed in Bicornes by Warming.

Pyrus (Tourn.) Linn. (incl. *Cydonia* Tourn., *Mespilus* Tourn.). Rosaceae (II. 4). 50 or 60 sp. N. temp.; 6 in Brit., incl. *P. Aucuparia* Ehrh., the rowan or mountain ash, *P. Malus* L. the apple, &c. The receptacle is hollowed out and united to the syncarpous ovary. The flrs. are protogynous, and are visited by bees and many other insects. Several varieties of pear (*P. communis* L.) are self-sterile (see Waite in *Bull. U.S. Agric. Dept.* 1894). After fertilisation the fruit becomes a large fleshy pseudocarp (*pome*), the flesh consisting of the enlarged receptacle, while the gynœceum forms the core. Several sp. are cultivated for their fruit, *e.g. P. Malus* L. (apple), *P. communis* L. (pear), *P. Cydonia* L. (quince), *P. germanica* Hook. f. (medlar). *P. japonica* Thunb. is often grown upon walls.

Quamoclit Tourn. ex Moench = Ipomœa Linn.

Quercus (Tourn.) Linn. (incl. *Pasania* Oerst.). Fagaceae. 300 sp. N. temp., Indo-mal., Pacific coasts, &c. The oaks are evergreen or deciduous trees, in the latter case especially with well-developed winter buds. The cupule contains 1 ♀ flr. only (see order), and forms the acorn-cup at the base of the nut in fruit. Some sp. of the subgenus *Pasania* have 3 ♀ flrs. The ♂ flrs. are solitary in pendulous catkins. Anemophilous. Many sp. are important economic plants. Among the most noteworthy are: *Q. Aegilops* L. (E. Eur., Orient), whose cupules and unripe acorns, known as Valonia, are used in tanning, *Q. alba* L. (N. Am.), the white or Quebec oak (timber), *Q. Cerris* L. (Eur., Orient), the Turkey oak (timber), *Q. Ilex* L. (Medit.), the holly oak (timber, bark for tanning), *Q. Robur* L. (Eur., W. As.), the British oak (it has two forms, *sessiliflora* Salisb., and *pedunculata* Ehrh.), yielding timber and tan-bark, *Q. Suber* L. (Medit.) the cork oak, whose bark, stripped off in thick layers and flattened, forms ordinary cork, *Q. tinctoria* Bartr. (N. Am.), whose bark (Quercitron bark) forms a yellow dye, and many others.

Quiina Aubl. Quiinaceae. 16 sp. trop. S. Am.

Quiinaceae. Dicotyledons (Archichl. Parietales). 2 gen. with 19 sp. trop. S. Am. Placed in Guttiferae by Benth.-Hooker.

Quillaja Molina. Rosaceae (I. 2). 3 sp. S. Am. *Q. Saponaria* Molina is the soap-tree of Chili; the powdered bark gives a lather with water.

Quinaria Rafin. = Vitis Tourn.

Quisqualis Linn. Combretaceae. 4 sp. trop. Afr., As. *Q. indica* L. is best known. "Up to a height of 1 m. this shrub grows erect with alt. leaves, and then emits long...often twining twigs, also with alt. leaves whose petiole is jointed some way from the base. After the leaf-fall the lower part forms a thorn. The flowering twigs have opp. leaves." (Brandis.) Fruit winged.

Radiola (Dill.) Roth. Linaceae. 1 sp. Eur. (incl. Brit.), N. Afr., temp. As., *R. linoides* Roth (all-seed). Infl. a dichasial cyme.

Rafflesia R. Br. Rafflesiaceae. 5 sp. Java, Sumatra, &c.; parasitic on Vitis roots. *R. Arnoldi* R. Br. has a colossal flr. a yard across and weighing 15 lbs. It smells like putrid meat, and is visited and pollinated by carrion flies (p. 92).

Rafflesiaceae. Dicotyledons (Archichl. Aristolochiales). 7 gen. with 22 sp. trop. An extremely interesting order of parasitic herbs, whose vegetative organs are reduced to what is practically a *mycelium* like that of a true Fungus, viz. a network of fine cellular threads ramifying in the tissues of the host (p. 176). The flrs. appear above ground, developing as adventitious shoots upon the mycelium. They are unisexual, and sometimes of enormous size. *Chief genera:* Rafflesia, Brugmansia, Pilostyles, Cytinus. Benth.-Hooker term the order Cytinaceae, and include in it the Hydnoraceae, placing the whole in Multiovulatae Terrestres, Warming places it in Hysterophyta.

Rafnia Thunb. Leguminosae (III. 3). 22 sp. S. Afr.

Ramondia Rich. Gesneriaceae (I). 4 sp. endemic on Mts. of S. Eur. (1 Pyrenees, 1 Olympus, 2 Servia; see p. 149). Flr. almost regular with 5 sta. and rotate corolla.

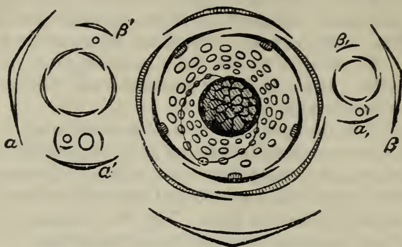
Ranales. The 11th cohort (Engler) of Archichlamydeae (p. 128). The first cohort (Benth.-Hooker) of Polypetalae (p. 132).

Randia Houst. ex Linn. Rubiaceae (I. 8). 100 sp. trop. The two leaves at a node are often unequal (p. 47) and one frequently aborts early. Thorns often occur. In *R. dumetorum* Lam. the thorn arises in the axil of a leaf above the ordinary bud, and is carried up by intercalary growth.

Ranunculaceae. Dicotyledons (Archichl. Ranales). 27 gen. with 700 sp., chiefly N. temp. and well represented in Brit. Most are herbaceous perennials with rhizomes, usually of condensed (root-stock) form, and always of sympodial construction. Each year's shoot ends in an infl. and a bud is formed in the axil of one of the leaves at the base, which forms the next year's growth. In most sp. the primary root soon dies away, and adventitious roots are formed from the stem; often (e.g. Aconitum, Ranunculus sp.) these swell up into tubers holding reserve materials. The leaves are usually alt., with sheathing bases and often very much divided. The chief exceptions to the above general statements, and special cases of interest, are described under the genera, e.g. Helleborus, Eranthis, Clematis, Ranunculus.

The infl. is typically determinate; in Anemone sp., Eranthis, &c., a single terminal flr. is produced. More often a cymose branching occurs, the buds in the axils of the leaves below the terminal flr.

developing in descending order. In Nigella sp. and others, after the terminal flr. is formed, the buds below develope in ascending order, so that a raceme with an end flr. is formed; in Aconitum &c. the same thing occurs, but the terminal flr. rarely developes. In Nigella,



Ranunculus acris. Floral diagram of axillary dichasial cyme, with details of primary flr. Sta. according to the $\frac{8}{21}$ phyllotaxy. *α β* bracteoles of primary, *α' β'*, *α, β,* of later, flrs. After Eichler.

Anemone, &c., there is an involucre of green leaves below the flr., usually alternating with the calyx.

The flr. itself is typically spiral upon a more or less elongated receptacle, but frequently the leaves of the perianth are in whorls. It is usually regular and ☿. The perianth is usually petaloid and rarely (*e.g.* Ranunculus) shows a true calyx and corolla. Frequently there occur nectaries of various patterns between the perianth proper and the sta.; these are usually considered as modified petals, but it is as probable that they are derived directly from sta. without having passed through the petal stage. An interesting series of transitions may be seen by comparing the following flrs. :—Caltha (honey secreted by cpls., 'calyx' present, nothing between it and sta.), Helleborus or Eranthis (honey secreted in little tubular 'petals'), Nigella (ditto, but 'petals' with a small leafy end), *Ranunculus auricomus* ('petals' distinct and coloured, with pocket-like nectary at base), *R. acris* &c. (petals large, nectary at base). In Aconitum and Delphinium there is a zygomorphic flr. The sta. are usually ∞ and spiral, the anthers extrorse; the cpls. ∞, apocarpous, spiral, with either one basal or several ventral anatropous ovules. In Nigella the cpls. are united; there is only 1 in Actaea, which thus forms a link to Berberidaceae.

As a rule the flrs. are protandrous and the sta., as their anthers open, bend outwards from the centre of the flr. A good series of flrs. showing various grades of adaptation to insects may be found in R. (cf. pp. 87 seq.), *e.g.* Clematis (pollen flr.), Ranunculus (actinomorphic, honey scarcely concealed at all), Nigella (honey in little closed cavities), Aquilegia (honey in long spurs), Delphinium (ditto. but zygomorphic also, and blue in colour), &c.

The fruit is a group of achenes or follicles (capsule in Nigella, berry in Actaea); seeds with minute embryo and oily endosperm. The R. are mostly poisonous; a few, *e.g.* Aconitum, are or have been medicinal.

Classification and chief genera (after Prantl):

A. Ovules many: fruit a follicle, berry or capsule.

1. *Paeonieae* (no honey leaves; flrs. usually solitary: ovary wall fleshy; stigma broadened): Paeonia.
2. *Helleboreae* (usually honey-leaves; ovary wall rarely fleshy and then flrs. in racemes; flrs. solitary or in cymes or racemes): Caltha, Trollius, Helleborus, Nigella, Eranthis, Actaea, Aquilegia, Delphinium, Aconitum.

B. Ovule one; fruit an achene.

3. *Anemoneae:* Anemone, Clematis, Ranunculus, Thalictrum.

[Placed in Ranales by Benth.-Hooker, in Polycarpicae by Warming.]

Ranunculus (Tourn.) Linn. Ranunculaceae (3). 250 sp. cosmop., esp. N. temp.; 15 in Brit., several of interest. *R. Ficaria* L. (pilewort or celandine) has tuberous roots, one formed at the base of each axillary bud; these may give rise by separation to new plants. *R. aquatilis* L. (water crowfoot) is often divided into a large number of so-called species (see pp. 119, 159); it has a floating stem bearing leaves which in many forms are of two kinds (*heterophylly*, p. 163), the submerged leaves being much divided into linear segments, whilst the floating leaves are merely lobed. *R. repens* L. (creeping buttercup or crowfoot) has creeping runners (p. 153) which root at the nodes and give rise to new plants. *R. acris* L. and *R. bulbosus* L. are other common buttercups; the latter has the base of the stem thickened for storage. The flrs. of R. are in cymes, regular, with well-marked calyx and corolla (see order for diagram). Honey is secreted in little pockets at the base of the petals. The flrs. are protandrous and visited by a miscellaneous lot of insects (p. 88).

Raoulia Hook. f. Compositae (IV). 18 sp. N. Z., Austr. Woolly herbs forming dense tufted masses (p. 165), easily mistaken at a distance for sheep; hence they are known as 'vegetable sheep.'

Rapatea Aubl. Rapateaceae. 5 sp. S. Am.

Rapateaceae. Monocotyledons (Farinosae). 6 gen. with 25 sp. S. Am. Placed in Coronarieae by Benth.-Hooker, in Liliiflorae by Warming. For details see *Nat. Pfl.*

Raphanus (Tourn.) Linn. Cruciferae (II. 10). 10 sp. Medit., Eur., Java. *R. Raphanistrum* L. in Brit.; its pods are jointed between the seeds (lomentose). *R. sativus* L. is the radish, a biennial with root-storage (p. 151).

Raphia Beauv. Palmae (III. 5). 6 sp. trop. Afr., *R. vinifera* Beauv. (the wine palm) occurring also on the Amazon (see order). Spadix monœcious; the bracts have a curious sheathing form. Berry enclosed in large sheathing scales. In *R. Ruffia* Mart. roots are developed between the dead leaf-bases; they curve upwards and are said to act as respiratory organs.

Ratonia DC. (*Matayba* Aubl.). Sapindaceae (I). 36 sp. trop. and subtrop. Am.

Ravenala Adans. Musaceae. 2 sp. Madag. and S. Am. They have a true sub-aerial stem, which bears large leaves in 2-ranked phyllotaxy, giving the plant a peculiar fan-like appearance. *R. guyanensis* Steud. is the only Am. sp. of the suborder *Museae*. *R. madagascariensis* J. F. Gmel. is the traveller's tree, so-called because the water that accumulates in the leaf-bases has been used for drinking in cases of necessity.

Reaumuria Linn. Tamaricaceae. 13 sp. E. Medit., Cent. As. Halophytes (p. 169). [See Volkens *Flora d. aegyptisch-arabische Wüste*.]

Reineckia Kunth. Liliaceae (VII). 1 sp. China, Japan.

Reinwardtia Dum. Linaceae. 1 sp. N. India.

Relhania L'Hérit. Compositae (IV). 18 sp. S. Afr.

Remusatia Schott. Araceae (VI). 2 sp. E. Ind., Java. *R. vivipara* Schott has a tuberous stem which gives off upright shoots bearing scale-leaves: in their axils are little tubers, each of which is provided with a terminal hook by which it may be carried away by an animal.

Renanthera Lour. Orchidaceae (31). 12 sp. Malaya, Cochin China. Climbers.

Renealmia Linn. f. Zingiberaceae. 15 sp. trop. Am., W. Afr.

Reseda Tourn. ex Linn. Resedaceae. 53 sp. Medit., Eur.; *R. lutea* L. and *R. Luteola* L. in Brit. *R. odorata* L. is the garden mignonette. There is a large posterior disc. The ovary and fruit are open at the apex. *R. lutea* is the dyer's weld; it yields a yellow dye.

Resedaceae. Dicotyledons (Archichl. Rhoeadales). 6 gen. with 45 sp. chiefly Medit., also in Eur., As., S. Afr., Calif. Most are xerophytic herbs with alt. stip. leaves and racemes of zygomorphic ☿ flrs., with bracts but without bracteoles. The axis developes posteriorly into a large disc, and upon this side the petals &c. are usually better developed than upon the anterior side of the flr. K 4—8; C 0—8; A 3—40; $\underline{G}$ (2—6) or 2—6, in the former case 1-loc. with parietal placentae. Ovary open at the top; ovules 1—∞ per cpl., anatropous. Fruit capsular; embryo curved; no endosperm. *Chief genera:* Reseda, Oligomeris. Placed in Parietales by Benth.-Hooker, in Cistiflorae by Warming.

Restiaceae (Benth.-Hooker) = Restionaceae.

Restio Linn. Restionaceae. 100 sp. S. Afr., Austr. *R. tetraphyllus* Labill. is often grown in botanic gardens. Assimilation is performed by the green stems, the leaves being reduced to sheaths.

Restionaceae. Monocotyledons (Farinosae). 19 gen. with about 250 sp., mostly in S. Afr. and Austr., a few in N. Z., Chili and Cochin China. Xerophytes (p. 163), usually of tufted growth, with the general habit of a Juncus; below ground is a rhizome with scaly leaves, giving off erect cylindrical shoots bearing sheathing leaves (rarely with ligules), which have a short blade, or sometimes none at all, in which case assimilation is performed by the stem. Flrs. diœcious (rarely monœcious or ☿), regular, in spikelets. Perianth in two whorls, but single members are often absent. Sta. 3 or 2, opp. to the inner perianth-leaves. Ovary superior, 1—3-loc., with 1 pendulous orthotropous ovule in each loc. Capsule or nut. Embryo lens-shaped, in mealy endosperm. *Chief genus:* Restio. Placed in Glumaceae by Benth.-Hooker, in Enantioblastae by Warming. See *Nat. Pfl.* for further details.

Restrepia H. B. et K. Orchidaceae (12). 12 sp. trop. Am.

Retinispora Sieb. et Zucc. = Thuya Linn., &c. Seedlings of many sp. of the genera Chamaecyparis, Cupressus, Thuya, &c., exhibit, instead of the decussate appressed leaves of the mature plant, spreading needle-leaves (often in whorls of 4) like those of Abies &c. (see p. 112 and cf. Pinus, Acacia, &c.). If now these young seedlings be used as offsets, the new plants thus formed retain throughout life this form of foliage; and plants are thus obtained of totally different habit from the ordinary habit of these genera. To these 'seedling forms' the name R. was given. Many are found in gardens. The synonymy of the chief of these is as follows: *R. decussata* hort. = *Thuya orientalis; R. filifera* Fowles = *Cupressus obtusa; R. juniperoides* Carr. = *Thuya orientalis; R. obtusa* Sieb. et Zucc. = *Cupressus obtusa; R. pisifera* Sieb. et Zucc. = *Cupressus pisifera; R. recurvata* hort. and *R. rigida* Carr. = *Thuya orientalis; R. squarrosa* Sieb. et Zucc. and *R. stricta* hort. = *Cupressus pisifera.* For further synonymy see *Index Kewensis.*

Rhagadiolus Tourn. ex Scop. (incl. *Hedypnois* Schreb. and *Garhadiolus* Jaub. et Spach). Compositae (XIII). 8 sp. Medit., Orient. The fruit is linear and has no pappus, being completely enwrapped in an involucral bract.

Rhamnaceae. Dicotyledons (Archichl. Rhamnales). About 40 gen. with 500 sp., found in all districts suited to the growth of trees. Nearly all are trees or shrubs, often climbing (by aid of hooks in Ventilago, tendrils in Gouania &c., twining stems in Berchemia): thorns occur in some, and especially in Colletia and its allies, to which a most peculiar habit is thereby imparted. In these plants too, serial buds occur in the leaf-axils. Leaves simple, usually with stipules, never lobed or divided. Infl. cymose, usually a corymb.

Flr. inconspicuous, ☿ or rarely unisexual, regular, sometimes apetalous. Receptacle hollow, free from or united to the ovary. K 5—4, valvate; C 5—4, usually small, often strongly concave, frequently clawed at base. Sta. 5—4, alt. with sepals, usually enclosed by the petals, at any rate at first. Disc usually well developed, intra-staminal. Ovary free or more or less united to receptacle, 3—2- (rarely by abortion 1-) loc. (sometimes 4- or typically 1-loc.); in each loc. 1

(rarely 2) basal ovule with downwardly-directed micropyle. Style simple or divided. Fruit dry, splitting into dehiscent or indehiscent mericarps, or a drupe with 1 or several stones, or a nut. Endosperm little or none. Many of the dry fruits show special adaptations for wind-carriage, *e.g.* Paliurus, Ventilago. The order is closely related to Vitaceae, from which it is chiefly distinguished by the small petals, the receptacle, the endocarp and simple leaves; it also approaches Celastraceae, the chief distinction being the antepetalous sta. *Chief genera:* Ventilago, Paliurus, Zizyphus, Rhamnus, Hovenia, Ceanothus, Phylica, Colletia, Gouania. Few are of economic value; see Zizyphus, Rhamnus, Hovenia. Benth.-Hooker place the order in Celastrales, Warming in Frangulinae.

Rhamnales. The 17th cohort of Archichlamydeae (p. 129).

Rhamneae (Benth.-Hooker) = Rhamnaceae.

Rhamnus Tourn. ex Linn. Rhamnaceae. 70 sp. N. temp., a few trop. and S. temp., 2 in Brit., *R. cathartica* L. the common or purging buckthorn, and *R. Frangula* L., the Alder buckthorn. The R. are shrubs with alt. or opp. leaves and small cymose clusters of flrs. The genus is divided into two sections. To § 1, *Eurhamnus* (flrs. usually 4-merous, polygamous or diœcious), belong *R. Alaternus* L. (Medit.) and *R. cathartica* (Eur., As., Medit.), whose berries possess active purgative properties; the juice of the fruit is mixed with alum and evaporated, thus forming the paint known as sap-green; also *R. infectoria* L. (Mts. of S. Eur.) whose berries are known as Graines d'Avignon or 'yellow berries' and yield useful green and yellow dye-stuffs, and *R. chlorophora* Dcne. from whose bark the Chinese prepare the dye known as 'Chinese green indigo' used in dyeing silk (*R. utilis* Dcne. is also employed). To § 2, *Frangula* (flrs. usually 5-merous, ☿), belong *R. Frangula* (Eur., As., N. Afr.) whose bark is officinal (cathartic) and whose wood forms one of the best charcoals for gunpowder, *R. Purshiana* DC. in N. Am., whose bark (Cascara sagrada) is largely used as a cathartic.

Rhaphidophora Hassk. Araceae (II). 25 sp. E. Ind. Plants with sympodial climbing stems with clasping roots and pendulous aerial roots. The pinnation of the leaves arises by a process similar to that which occurs in Monstera, *i.e.* by long holes arising between the ribs, and the margin finally breaking. Flrs. ☿.

Rhapis Linn. f. Palmae (I. 2). 5 sp. E. As.

Rheum Linn. Polygonaceae (I. 2). 20 sp. temp. and subtrop. As. The flrs. are like those of Rumex, but are coloured and entomophilous, though they exhibit traces of anemophilous nature in their very large stigmas (cf. Poterium &c.). *R. officinale* Baill. furnishes medicinal rhubarb; *R. Rhaponticum* L. is the rhubarb used as a vegetable.

Rhexia Linn. Melastomaceae (I). 7 sp. East U.S.

Rhinanthus Linn. (incl. *Fistularia* Linn.). Scrophulariaceae (III. 12).

11 sp. Eur., Medit.; 2 in Brit. (yellow-rattle), common in damp pastures. Semi-parasites with loose pollen flrs. (see order).

Rhipsalis Gaertn. Cactaceae (I. 3). 50 sp. trop. Am., Madag., Ceylon (see order). Epiphytes, rarely thorny, sometimes of Cereus-like structure, sometimes Phyllocactus-like, or with cylindrical stems (compare sp. of Euphorbia). Fruit fleshy.

Rhizoboleae = Caryocaraceae.

Rhizophora Linn. Rhizophoraceae. 3 sp., *R. Mangle* L. in Am., *R. mucronata* Lam. and another, Japan to E. Afr. These mangroves (p. 191) are moderate-sized trees with a great development of roots from the stem and branches. On the sub-aerial parts of the roots are large lenticels, probably serving in the same way as the aerenchyma of Bruguiera &c. The seed germinates upon the tree, the hypocotyl projects at the micropyle and grows rapidly. The bark is used for tanning, yielding a substance known as cutch (cf. Acacia).

Rhizophoraceae. Dicotyledons (Archichl. Myrtiflorae). 12 gen. with 50 sp. trop., mostly Old World. The general habit of the mangroves is described on p. 188. They are trees with opp. stip. leaves; flrs. solitary or in cymes &c., ☿, hypo- to epi-gynous. K usually 4—8; C 4—8; A 8—∞, inserted on outer edge of perigynous or epigynous disc; G (2—5), 2—5-loc. with usually 2 anatropous pendulous ovules in each loc. Fruit a slightly soft berry. *Chief genera* · Rhizophora, Bruguiera. Placed in Myrtales by Benth.-Hooker, in Myrtiflorae by Warming.

Rhodea Endl. = Rohdea Roth.

Rhodochiton Zucc. Scrophulariaceae (II. 5). 1 sp. Mexico, *R. volubile* Zucc., a favourite greenhouse twiner with sensitive petioles (cf. Clematis).

Rhododendron Linn. (incl. *Azalea* Linn., q.v.). Ericaceae (I. 2). 200 sp. "One sp. (*R. Lochae* F. Muell.) is found in trop. Austral., the greatest richness of sp. is in E. Asia, from S. China to the Himalaya and Japan; a second and lesser abundance is found in temp. N. Am., and a few sp. in the arctic regions. 4 sp. in Mid. and S. Eur., 5 in Caucasus. The alpine sp. are called 'alpine roses.'" (Drude.) Many sp. and hybrids are cultivated. They are shrubs and small trees with leathery leaves; the leaves of § *Azalea* last one year, those of the other subgenera usually more. Large winter buds are formed covered with scale leaves; the larger and stouter ones contain infls., the slender ones merely leaves. The branch bearing an infl. is continued by the formation of a bud in one of the upper leaf axils. Some of the Indian sp. are epiphytic. The corolla is slightly zygomorphic, and the sta. and style bend upwards to touch the under surface of a visiting insect. *R. ferrugineum* L., the alpine rose, is protandrous and visited by humble-bees.

Rhodotypos Sieb. et Zucc. Rosaceae (III. 5). *R. kerrioides* S. et Z., the only sp. (Japan), is a favourite garden shrub. It has opp. leaves, found in no other plant of the order, except in seedlings of Prunus. There is an epicalyx (see Potentilla).

Rhoeadales. The 12th cohort of Archichlamydeae (p. 128).

Rhoeadinae (Warming). The 9th cohort of Choripetalae (p. 137).

Rhus (Tourn.) Linn. (incl. *Cotinus* Tourn. and *Toxicodendron* Tourn.). Anacardiaceae (III). 120 sp. subtrop. and warm temp. *R. Coriaria* L. is the Sumac (S. Eur.); its leaves, ground fine, are used for tanning and dyeing. *R. Toxicodendron* L. (N. Am.) is the poison-ivy, climbing with roots like ivy. Its juice produces ulcerations or erysipelas. *R. Cotinus* L. (Medit. to China) is the wig-tree, often cultivated in shrubberies. The flrs. are polygamous. The fruits are dispersed in a curious way. The stalk of each drupe remains smooth, but the sterile parts of the panicle lengthen and become very hairy. Then when ripe the stalks become detached at their joints, and the whole infl., with the fruits on it, falls to the ground and may be blown about by the wind, it being exceedingly light in proportion to its size. The wood yields the yellow dye known as 'young fustic.' *R. vernicifera* DC. is the lacquer-tree. Japan lacquer is obtained from notches in the stem. *R. succedanea* L. is the wax-tree of Japan; its crushed berries yield wax.

Rhynchospora Willd. = Rynchospora Vahl.

Ribes Linn. Saxifragaceae (VI). 50 sp. N. temp. and Andine; 4 in Brit. Shrubs, often with spines (emergences), and with racemes of flrs. on 'short shoots.' Ovary inferior, with two parietal placentae. Flrs. usually homogamous, with self-pollination in default of insect-visits. *R. alpinum* L. is diœcious. In *R. sanguineum* Pursh (common in shrubberies, and known as flowering currant) the petals change from white to pink as the flrs. grow older, and in *R. aureum* Pursh from yellow to carmine (see Fumaria, Boraginaceae). *R. rubrum* L. is the red, *R. nigrum* L. the black currant, *R. Grossularia* L. the gooseberry, all largely cultivated for their fruits.

Richardia Kunth. (*Zantedeschia* Spreng.). Araceae (V). 6 sp. S. Afr., including *R. africana* Kunth, the common 'Arum lily' of green-houses.

Richea R. Br. Epacridaceae. 8 sp. Tasmania, Victoria.

Ricinus (Tourn.) Linn. Euphorbiaceae (A. II. 1). 1 sp. Afr., *R. communis* L. the castor-oil plant, a shrub in tropical countries, a herbaceous plant in our gardens. Monœcious. The ♂ flr. has much-branched sta. The fruit explodes into the separate cpls., which at the same time open and drop the seeds. The seed is rich in oil, which is used medicinally and as a lubricant.

Rindera Pall. Boraginaceae (IV. 1). 10 sp. Medit., Eur., As.

Rinorea Aubl. = Alsodeia Thou.

Rivina Plum. ex Linn. Phytolaccaceae. 5 sp. trop. Am. P 4, A 4 or 8, $\underline{G}$ 1. Berry.

Robinia Linn. Leguminosae (III. 6). 6 sp. N. Am. *R. Pseud-acacia* L.

(false Acacia, locust) is cultivated in S. Brit. Stipules thorny. The leaflets move upwards in hot or dry air. The horizontal shoots branch in one plane, while the upright show radial symmetry (p. 47). The base of the petiole forms a cap protecting a series of axillary buds.

Rochea DC. Crassulaceae. 4 sp. S. Afr. [For *R. falcata* DC. see Crassula.]

Rodgersia A. Gray. Saxifragaceae (I). 1 sp. China, Japan.

Rodriguezia Ruiz et Pav. Orchidaceae (28). 25 sp., epiphytic, in trop. Am. Between successive tubers there is often a long stretch of rhizome.

Roella Linn. Campanulaceae (I. 1). 11 sp. S. Afr.

Roemeria Medic. Papaveraceae (II). 3 sp. Medit. to Afghanistan. *R. hybrida* DC. has become established as a cornfield weed in Norfolk and Cambridgeshire.

Roettlera Vahl = Didymocarpus Wall.

Rohdea Roth. Liliaceae (VII). 1 sp. *R. japonica* Roth, Japan. "It is, according to Delpino, a link between the Asparagoideae and the Araceae. It possesses a kind of spadix, on which the flrs. are arranged in a close uninterrupted spiral. The fact that the limb of the perianth is spread out exactly on a level with the points of the anthers and stigma led D. to think that fertilisation was effected by small animals crawling over the flrs. He observed snails (*Helix aspersa* &c.) greedily eating the perianth, which is yellow and fleshy; after devouring about 10 flrs. they crawled to another spadix. Only those flrs. on which the snails had crawled proved fertile; the flrs. were found to be barren to their own pollen. These observations leave no doubt that snails are really efficient fertilising agents." (Müller.)

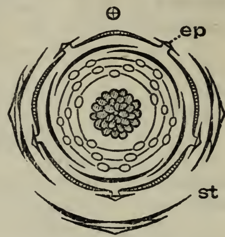
Romulea Maratti. Iridaceae (I). 50 sp. Eur., Medit. (1 Brit., rare).

Rondeletia Linn. Rubiaceae (I. 3). 60 sp. trop. Am.

Roridula Linn. Droseraceae. 2 sp. S. Afr. Like Drosera, but with no movement of the leaf-tentacles.

Rosa Tourn. ex Linn. Rosaceae (III. 10). 100 sp. N. temp. and on trop. mts.; 6 in Brit., incl. *R. canina* L., the dog-rose. A variable genus like Rubus (pp. 117, 119). The flr. of *R. canina* is a pollen flr. (p. 88). The fruit (hip) consists of a number of achenes enclosed in the fleshy receptacle which closes over them after fertilisation. *R. centifolia* L. is the form from which the cabbage rose is derived; and numerous forms of this and other sp. are cultivated (see *Nat. Pfl.*). The thorns of roses are mere epidermal appendages.

Rosaceae. Dicotyledons (Archichl. Rosales). 90 gen. with 2000 sp. cosmop. Trees, shrubs and herbs, usually perennial; leaves alt. (exc. Rhodotypos), simple or compound, usually stip., the stipules often adnate to the petiole. Vegetative multiplication occurs in various ways, but especially by creeping stems—runners as in strawberry, or suckers as in raspberry. The flrs. are terminal, in racemose or cymose infls. of various types, and show a great variety of forms. The receptacle is generally hollowed to a greater or less extent, so that various degrees of perigyny occur. Frequently there is a central protuberance bearing the cpls., even in the forms with very much hollowed receptacle. In a few cases (suborders II, IV) the cpls. are united to the receptacle and fully inferior. The receptacle often forms a part of the fruit. The flr. is usually ☿ and actinomorphic. K 5, often with an epicalyx of outer and smaller leaves (see Potentilla), usually imbricate; C 5, usually imbricate; A 2, 3 or 4 times as many as petals, or ∞, bent inwards in bud; G usually apocarpous and superior, rarely syncarpous or inferior; cpls. as many or 2 or 3 times as many as petals or ∞ or 1—4. Ovules anatropous, usually 2 in each cpl. Style often lateral or basal. Fruit various, dry or fleshy; often an aggregate of achenes (Potentilla) or drupes (Rubus), or a single drupe (Prunus), or pome (Pyrus), and so on (see p. 108 and genera, esp. those mentioned, and Fragaria, Geum, Rosa, Poterium). Seed usually exalbuminous.



Floral Diagram of *Potentilla fruticosa* (after Eichler). ep. = epicalyx, st. = stipules of bracts and bracteoles.

The flrs. in general are of simple type, with but slightly concealed honey (p. 90) and ∞ sta. (p. 123). They are usually protandrous. Poterium sp. are anemophilous.

Few are of economic value (see Pyrus, Rubus, Fragaria, Prunus), but many are favourites as garden plants and shrubs.

Classification and chief genera (after Focke in *Nat. Pfl.*, q.v.). R. are very closely related to Saxifragaceae, some genera being almost arbitrarily placed in one order or the other; they are also nearly allied to Calycanthaceae, Combretaceae, Myrtaceae (the floral diagram of M. is practically the same as that of suborder II), Thymelaeaceae, and Leguminosae (through suborder VI).

I. *SPIRAEOIDEAE* (cpls. 12—1, usually 5—2, whorled, neither on special carpophore nor sunk in receptacle, with 2 or more ovules in each; fruit usually dehiscent; sta. on broad base, tapering upwards; stipules often absent):
  1. *Spiraeeae* (follicle, seeds not winged): Spiraea.
  2. *Quillajeae* (follicle, seeds winged): Quillaja.
  3. *Holodisceae* (achene): Holodiscus.

II. *POMOIDEAE* (cpls. 5—2, united to inner wall of receptacle, usually syncarpous; axis fleshy in fruit, stipules):
  4. *Pomarieae:* Pyrus.

III. *ROSOIDEAE* (cpls. ∞ or rarely 1 on carpophore, sometimes enclosed in axis in fruit; fruit 1-seeded indehiscent):

5. *Kerrieae* (stips. distinct; axis not forming part of fruit; sta. tapering upwards from broad base; cpls. few, whorled; sta. ∞): Rhodotypos, Kerria.

6. *Potentilleae* (as 5, but cpls. usually ∞, in a head, or rarely few and then sta. also few):

6 a. Rubinae (drupes, no epicalyx): Rubus.

6 b. Potentillinae (achenes; seed pendulous; usually epicalyx): Fragaria, Potentilla.

6 c. Dryadinae (as b, but seed erect): Geum, Dryas.

7. *Cercocarpeae* (stipules slightly developed; torus tubular; cpl. 1; achene): Adenostoma, Purshia.

8. *Ulmarieae* (torus flat or nearly so; sta. with narrow base): Ulmaria.

9. *Sanguisorbeae* (torus cup-like enclosing cpls., hardening in fruit; cpls. 2 or more): Alchemilla, Agrimonia, Poterium.

10. *Roseae* (torus cup-like or tubular, enclosing ∞ cpls., and fleshy in fruit): Rosa.

IV. *NEURADOIDEAE* (cpls. 5—10 syncarpous and united to torus, which is dry in fruit; herbs).

11. *Neuradeae:* Neurada.

V. *PRUNOIDEAE* (cpl. 1, rarely 2—5, free of torus; drupe; trees with simple leaves; style almost terminal; ovules pendulous; flrs. regular).

12. *Pruneae:* Nuttallia, Prunus.

VI. *CHRYSOBALANOIDEAE* (as V, but style basal and ovules erect):

13 a. Chrysobalaninae (nearly regular): Chrysobalanus.

13 b. Hirtellinae (zygomorphic): Hirtella.

[Placed in Rosales by Benth.-Hooker, in Rosiflorae by Warming, who splits up the order considerably.]

Rosales. The 14th cohort (Engler) of Archichlamydeae (p. 128). The 11th cohort (Benth.-Hooker) of Polypetalae (p. 133).

Rosiflorae (Warming). The 19th cohort of Choripetalae (p. 137).

Roscoea Sm. Zingiberaceae. 4 sp. Himal. *R. purpurea* Sm. is often cultivated. It has a zygomorphic flr. with two lips. Insects landing on the lower and probing for honey find their way obstructed by two projecting spikes from the lower end of the anther; pressure on these brings the anther (with the stigma, which projects beyond it) down upon the insect's back. The flr. is protandrous. [Cf. Salvia.]

Rosmarinus (Tourn.) Linn. Labiatae (I. 2). 1 sp. Medit., *R. officinalis* L., the rosemary, a xerophytic shrub with leaves rolled back and stomata in hairy grooves on lower side (cf. Ericaceae, Empetrum). Oil of rosemary is employed in perfumery &c.

Rotala Linn. Lythraceae. 32 sp. trop. and subtrop., in wet places.

Rottboellia Linn. f. (excl. *Ophiurus* Gaertn. f.). Gramineae (II). 30 sp. trop.

Roupala Aubl. Proteaceae (II). 39 sp., 1 in Austr., 2 in New Caled., the rest in trop. Am.

Rourea Aubl. Connaraceae. 40 sp. trop.

Roxburghia Banks = Stemona Lour.

Roxburghiaceae (Benth.-Hooker) = Stemonaceae.

Roydsia Roxb. Capparidaceae (IV). 3 sp. Indo-mal.

Royena Linn. Ebenaceae. 13 sp. Afr. *R. lucida* L. yields useful timber.

Rubia (Tourn.) Linn. Rubiaceae (II. 21). 5 sp. Eur., As., Afr., S. Am. (1 in Brit.). *R. tinctorum* L. is the madder, formerly largely cultivated for its dye (alizarin), which is now prepared artificially.

Rubiaceae. Dicotyledons (Sympet. Rubiales). 350 gen. with 4500 sp. forming one of the largest orders of plants. Most are trop., but a number (esp. of the *Galieae*) are temp., and Galium itself has a few arctic sp. Trees, shrubs and herbs with decussate stip. entire or rarely toothed leaves. The stipules exhibit great variety of form; they stand either between the petioles (*interpetiolar*) or between the petiole and the axis (*intrapetiolar*). They are frequently united to one another and to the petioles, so that a sheath is formed round the stem. The two stipules—one from each leaf—that stand side by side are usually united, and in the *Galieae*, to which the Brit. sp. belong, are leaf-like, and often as large as the ordinary leaves; a characteristic appearance is thus produced, the plants seeming to have whorls of leaves; and it is only by noting the axillary buds that a clue is obtained to the real state of affairs. The number of organs—leaves and stipules—in a whorl varies from 4 upwards, according to the amount of 'fusion' or 'branching' of the stipules. The simplest case is a whorl of 6, each leaf having 2 separate stipules; if the stipules be united in pairs, a whorl of 4 results; if each stipule be branched into two, we get a whorl of 10, and, if the centre pair of half-stipules on either side be united, a whorl of 8, and so on.

Several R. are myrmecophilous (p. 115, and cf. Cecropia, Acacia), *e.g.* Myrmecodia, Cuviera, Duroia, Hydnophytum.

The infl. is typically cymose. Solitary terminal flrs. are rare; small dichasia are more frequent; the most common case is a much branched cymose panicle.

The flr. is usually ☿, regular, epigynous, 4- or 5-merous. K 4—5, epigynous, often almost absent, usually open in aestivation, sometimes with one sepal larger than the rest and brightly coloured (Mussaenda &c.); C (4—5), epigynous, valvate, convolute, or imbricate; A 4—5, alt. with petals, epipetalous; $\overline{G}$ (2) rarely (1—∞), 2-loc. with 1—∞ anatropous ovules in each loc.; ovules erect, pendulous, or horizontal; style simple; stigma capitate or lobed. Fruit a capsule (septi- or loculi-cidal), berry or schizocarp. Embryo small, in rich endosperm.

Most R. have conspicuous insect-pollinated flrs. The Brit. sp.

have small flrs. with freely exposed or but slightly concealed honey, and are chiefly visited by flies (see p. 89); of the trop. sp. many have bee- and Lepidoptera-flrs. with long tubes. Honey is usually secreted by an epigynous nectary round the base of the style. Heterostylism is common, and diœcism sometimes occurs. [See Burck in *Ann. Buitenz.* III. 1883, and IV. 1884.]

Several R. are of economic importance, *e.g.* Cinchona, Coffea, Uragoga, Rubia, &c.

Classification and chief genera (after Schumann). The R. are closely allied to Caprifoliaceae (q.v.) and less nearly to Compositae &c.

I. *CINCHONOIDEAE* (ovules ∞ in each loculus).

A. CINCHONINAE (fruit dry):

α. Flrs. solitary or in decussate panicles.

a. Flr. regular; seed not winged; corolla valvate.

1. *Condamineeae:* Condaminea.

2. *Oldenlandieae:* Oldenlandia, Houstonia, Pentas.

b. As a, but corolla imbricate or convolute.

3. *Rondeletieae:* Rondeletia.

c. As b, but seed winged.

4. *Cinchoneae:* Cinchona, Bouvardia, Cosmibuena.

d. As a, but corolla 2-lipped.

5. *Henriquezieae:* Henriquezia.

β. Flrs. in heads.

6. *Naucleeae:* Uncaria, Nauclea.

B. GARDENINAE (fruit fleshy):

7. *Mussaendeae* (corolla valvate): Mussaenda.

8. *Gardenieae* (corolla imbricate or convolute): Randia, Gardenia, Posoqueria, Duroia.

II. *COFFEOIDEAE* (ovules 1 in each loculus).

A. GUETTARDINAE (ovule pendulous; micropyle facing upwards):

9. *Alberteae:* Alberta.

10. *Knoxieae:* Knoxia.

11. *Vanguerieae:* Plectronia, Cuviera.

12. *Guettardeae:* Guettarda.

13. *Chiococceae:* Chiococca.

B. PSYCHOTRIINAE (ovule ascending; micropyle facing downwards):

α. Corolla convolute.

14. *Ixoreae:* Coffea, Ixora, Pavetta.

β. Corolla valvate.

a. Ovules inserted at base of loculus.

15. *Psychotrieae:* Psychotria, Rudgea, Uragoga, Lasianthus, Myrmecodia.

16. *Paederieae:* Paederia.

17. *Anthospermeae:* Nertera, Coprosma, Mitchella.

18. *Coussareeae:* Faramea.

b. Ovules on septum.

19. *Morindeae* (stip. undivided, not leafy; trees and shrubs): Morinda.
20. *Spermacoceae* (stip. divided; shrubs and undershrubs): Borreria.
21. *Galieae* (stip. leafy; herbs): Sherardia, Crucianella, Asperula, Galium, Rubia.

[Placed in Rubiales by Benth.-Hooker and Warming.]

Rubiales. The 7th cohort (Engler) of Sympetalae (p. 131). The 1st cohort (Benth.-Hooker) of Gamopetalae (p. 134). The 8th cohort (Warming) of Sympetalae (p. 138).

Rubus (Tourn.) Linn. Rosaceae (III. 6 a). A dominant and largely varying genus (p. 119) comprising perhaps 200 sp., most of which are represented by a large number of varieties, often, as in the cases of Rosa, Salix, and Hieracium, raised to specific rank in local floras, &c. The genus occurs in almost all parts of the world, especially N. temp. regions (5 or 6 sp. in Brit.). The flrs. are conspicuous; honey is secreted by a ring-shaped nectary upon the hollowed axis just within the insertion of the sta. The flrs. are homogamous, and visited by many insects, including bees. The fruit is an aggregate of drupes. Several sp. present special points of interest. *R. Chamaemorus* L. is the cloudberry, an arctic plant found in Scotland on the hills. It has creeping underground stems by means of which a large vegetative multiplication is carried on. The flrs. are solitary, terminal and unisexual. Occasionally ☿ flrs. occur. The plant is always described as diœcious, but it has been stated that there is sometimes a difference in sex between two plants, one of which appears to have sprung vegetatively from the other. *R. Idaeus* L. is the raspberry. It multiplies largely by suckers—stems which grow out horizontally beneath the soil to some distance, then turn up and give rise to new plants which flower in their second year. *R. fruticosus* L. is a general specific name for the innumerable varieties of the common bramble or blackberry. It is a hook-climber (the hooks being emergences) sprawling over the surrounding vegetation. Branches which reach the soil often take root there and grow up into new plants. *R. caesius* L. is the dewberry, whose fruits are covered with bloom (wax) like grapes. *R. occidentalis* L. is the black-cap raspberry or thimbleberry of N. Am. *R. australis* Forst. f. is an interesting sp. with the blades of the leaves reduced to the minimum (p. 166).

Rudbeckia Linn. (excl. *Lepachys* Rafin.). Compositae (V). 30 sp. N. Am.

Rudgea Salisb. Rubiaceae (II. 15). 100 sp. trop. Am. Some are heterostyled.

Ruellia Plum. ex Linn. Acanthaceae (IV. A). 200 sp. trop. and subtrop. The capsule explodes. The seeds possess surface hairs which, when wetted, swell and adhere to the soil.

Rumex Linn. Polygonaceae (I. 2). 100 sp. esp. in N. Temp. zone (12

British, of which several, known as docks and sorrels, are among our commonest plants). Flrs. of the type usual in the order, wind-fertilised, with large stigmas (see order for diagram, and cf. Rheum). *R. Hydrolapathum* Huds. is said to produce aerating roots like a mangrove (p. 161). The roots of *R. hymenosepalus* Torr. (N.W. Am.), the Canaigré, are used for tanning.

Ruppia Linn. Potamogetonaceae. 1 sp., *R. maritima* L., in salt or brackish water, temp. and subtrop. A slender swimming plant, with the habit of a small-leafed Potamogeton. The flrs. are borne just at the surface of the water, where fertilisation occurs by pollen floating upon the surface. Each spike consists of 2 flrs. not enclosed in the spathe at the flowering time. The flr. has 2 sta. with small outgrowths from the connectives, and four cpls.

Ruprechtia C. A. Mey. Polygonaceae (III. 6). 20 sp. S. Am.

Ruscus (Tourn.) Linn. Liliaceae (VII). 3 sp. Medit., Eur. *R. aculeatus* L., butcher's broom, in Brit., a small shrub. In the axils of scaly leaves stand leaf-like phylloclades; halfway up each is another scaly leaf, in whose axil stands the flr. Fruit a berry.

Russelia Jacq. Scrophulariaceae (II. 6). 6 sp. Mexico, Chili. *R. juncea* Zucc. is often cultivated in greenhouses. It is a xerophyte with much reduced leaves and pendulous green stems. Shoots sometimes appear under cultivation with broad leaves (reversion to ancestral type).

Ruta (Tourn.) Linn. Rutaceae (II). 50 sp. Medit., As. *R. graveolens* L., the rue, is commonly cultivated in Brit. It is a strongly smelling shrub owing to the presence in the leaves &c. of an ethereal oil. The terminal flr. of the infl. is 5-merous, the lateral flrs. 4-merous. The sta. lie in pairs in the boat-like petals; one by one they bend upwards over the stigma, dehisce and fall back; when all have done this, the stigma ripens, and finally the sta. again move up and effect self-fertilisation. The dirty-yellow strongly-scented flrs. are chiefly visited by small flies. Rue is employed in medicine as a narcotic and stimulant.

Rutaceae. Dicotyledons (Archichl. Geraniales). 100 gen. with 800 sp. trop. and temp., esp. S. Afr. and Austr. Most are shrubs and trees, often xerophytic and frequently of heath-like habit (e.g. Diosma). Leaves alt. or opp., exstip., usually compound, with glandular dots, often aromatic. In many *Aurantieae* there are short shoots whose leaves are reduced to thorns (cf. Cactaceae). Infl. of various forms, usually cymose. Flr. ☿, rarely unisexual, regular or zygomorphic, 5—4-merous (see Ruta), with a large disc below the gynœceum. K 5 or 4, the odd sepal posterior; C 5 or 4, imbricate; A 10 or 8, obdiplostemonous, or 5, 3, 2, or ∞, with introrse anthers; $\underline{G}$ (5 or 4), rarely (3—1) or (∞), often free at base and united above by the style (cf. Apocynaceae), multiloc.; ovules 2—∞ in each loc., anatropous with ventral raphe and micropyle facing upwards. Fruit various; schizocarps, drupes, berries, &c. Seeds with or without endosperm.

Several R. are or have been used in medicine, chiefly on account of the oils they contain, *e.g.* Ruta, Galipea, Toddalia, &c. Citrus yields important fruits, and Chloroxylon a dye-stuff.

Classification and chief genera (after Engler): The groups of R. differ considerably among themselves, and several of them were formerly regarded as independent orders. The relationships to allied orders are thus given by Engler:

$$\left.\begin{array}{l}\text{Zygophyllaceae}\\ \text{Cneoraceae}\end{array}\right\} \longleftarrow \longrightarrow \left\{\begin{array}{l}\text{Meliaceae}\\ \text{Burseraceae}\\ \text{Simarubaceae}\end{array}\right.$$

$$\begin{array}{c}\downarrow\\ \text{Rutaceae}\end{array}$$

The characters of only a few of the sub-orders are given here.

A. Cpls. usually 4—5, rarely 3—1 or more, often only united by style, ± divided when ripe; loculicidal dehiscence usually with separation of endocarp; rarely 4—1 fleshy drupes.

RUTOIDEAE.

I. *Zanthoxyleae:* Zanthoxylum, Choisya.
II. *Ruteae:* Ruta, Dictamnus.
III. *Boronieae:* Boronia, Eriostemon, Correa.
IV. *Diosmeae:* Calodendron, Adenandra, Diosma.
V. *Cusparieae:* Almeidea, Galipea, Cusparia.

DICTYOLOMOIDEAE.

VI. *Dictyolomeae:* Dictyoloma.

B. *FLINDERSIOIDEAE.*

VII. *Flindersieae:* Flindersia, Chloroxylon.

C. *SPATHELIOIDEAE.*

VIII. *Spathelieae:* Spathelia.

D. *TODDALIOIDEAE.*

IX. *Toddalieae:* Ptelea, Toddalia, Skimmia.

E. Berry, often with periderm, and with pulp derived from sappy emergences of cpl. wall. Seeds exalbuminous, often with 2 or more embryos. Lysigenous oil glands.

AURANTIOIDEAE.

X. *Aurantieae:* Glycosmis, Limonia, Atalantia, Feronia, Aegle, Citrus.

[Benth.-Hooker place the order in Geraniales, but add sub-order VII. to Meliaceae. Warming places it in Terebinthinae.]

Rynchospora Vahl. Cyperaceae (11). 150 sp. N. temp.; 2 in Brit.

Sabal Adans. Palmae (I. 2). 8 sp. Am.

Sabbatia Adans. Gentianaceae (I. 2). 12 sp. N. Am.

Sabia Colebr. Sabiaceae. 17 sp. S. and E. As.

Sabiaceae. Dicotyledons (Archichl. Sapindales). 4 gen. with 65 sp. trop. and E. As. Trees, shrubs or lianes with alt. exstip. imparipinnate or simple leaves. Infl. a panicle or cymose panicle, with bracts and bracteoles. Flrs. usually ☿. K (3—5), imbricate or free;

C 4—5, sometimes united at base, imbricate, the inner 2 much reduced; A 5, opp. petals, all or only 2 fertile, the rest being staminodial; ovary superior 2-loc.; in each loc. usually 2 axile pendulous or horizontal semi-anatropous ovules with micropyle upwards. Indehiscent fruit with exalbuminous seeds. *Chief genera:* Sabia, Meliosma. Placed in Sapindales by Benth.-Hooker.

Saccharum Linn. Gramineae (II). 12 sp. trop., esp. Old World. The most important is *S. officinarum* L., the sugar cane, a native (?) of trop. E. As., now cultivated in most trop. regions. From the rhizome there spring each year shoots which may reach a height of 12—15 feet and a thickness of 2 inches; the outer tissues have much silica in their cell-walls. The infl. is a dense woolly spike, the first and second glumes of each spikelet being covered with long hairs. The cultivated form has always been vegetatively propagated (pieces of the halm, each bearing a bud, are planted), but recently a more vigorous race has been raised from seed (cf. pp. 56 seq.). The sugar is contained in the soft central tissues of the stem; the canes are cut before flowering and crushed between rollers to extract the juice, which undergoes various subsequent processes.

Saccoglottis Endl. Humiriaceae. 10 sp. trop. Am., Afr.

Saccolabium Blume. Orchidaceae (31). 20 sp. Indo-mal. Epiphytes.

Sadleria Kaulf. Polypodiaceae. 2 sp. Sumatra, Sandwich Is.

Sagina Linn. Caryophyllaceae (II. 1). 20 sp. N. temp.; 4 in Brit. (pearl-wort). Small herbs with inconspicuous, sometimes apetalous flrs.; these are homogamous and pollinate themselves.

Sagittaria Rupp. ex Linn. Alismaceae. 12 sp., 11 in Am., the other, *S. sagittifolia* L. (arrow-head) in Eur. (incl. Brit.). It is a water-plant with a short rhizome bearing leaves of various types, the number of each kind depending on the depth of the water, &c. (see p. 160, and Goebel's *Pflanzenbiol. Sch.* II. p. 290). The fully submerged leaves are ribbon-shaped, the floating ones have an ovate blade, whilst those (usually the majority) that project above water are arrow-shaped (sagittate). In the leaf-axils are formed the 'renewal' shoots which last over the winter; these are short branches which burrow into the mud and swell up at the ends each into a large bud whose central axis is swollen with reserve-materials; in spring this developes into a new plant. The diclinous racemose infl. projects above water; the ♀ flrs. are lower down than the ♂. The ♂ contains ∞ sta., the ♀ ∞ cpls. The flrs. contain honey, and are visited by flies.

Sagus Rumph ex Gaertn. = Metroxylon Rottb.

Saintpaulia H. Wendl. Gesneriaceae (I). 1 sp. E. Afr., *S. ionantha* H. Wendl., a recent discovery, but already cultivated in botanic gardens and likely to become popular. The flr. resembles in appearance that of Exacum, and exhibits a similar dimorphic symmetry. In some of the flrs. the style projects to the left over the corolla, in others to the right (cf. Exacum, Cassia).

Salacia Linn. Hippocrateaceae. 80 sp. trop. S. Am., a few in trop. Afr., As., Austr. Many are lianes with dimorphic branches, one form being adapted for climbing (p. 172).

Salaxis Salisb. Ericaceae (IV. 10). 22 sp. Cape Colony.

Salicaceae. Dicotyledons (Archichl. Salicales). 2 gen. with 180 sp. N. temp., trop. and subtrop. Shrubs or trees with stip. leaves and much vegetative propagation by suckers. Flrs. naked, in catkins or spikes, diœcious (many hybrids exist). The catkins arise in autumn and remain as buds through the winter, developing in early spring. The ♂ flr. consists of 2—30 sta. in the axil of a bract, the ♀ usually of (2) cpls. transversely placed, syncarpous with parietal placentation; ovules ∞, anatropous. Seeds exalbuminous with basal tufts of hairs. Placed in Saliciflorae by Warming, as an anomalous order at the end of Incompletae by Benth.-Hooker. *Genera:* Salix, Populus.

Salicales. The 3rd cohort of Archichlamydeae (p. 127).

Saliciflorae (Warming). The 1st cohort of Choripetalae (p. 137).

Salicornia (Tourn.) Linn. Chenopodiaceae (7). 9 sp. on sea-coasts. *S. herbacea* L. (saltwort) cosmop., incl. Brit. (p. 187). Succulent herbs, with the habit of a cactus, leafless and with jointed nodes. Flrs. in groups of 3 or more, one group sunk in the tissue on either side of each internode. Perianth fleshy; sta. 1 or 2.

Salisburia Sm. = Ginkgo Linn.

Salix (Tourn.) Linn. Salicaceae. 160 sp., chiefly N. temp. The sp. are very variable and there are many hybrids (cf. Rubus, Rosa, and see Ch. II.). 12 in Brit. (willow, sallow, &c). The branching is monopodial, but the terminal bud usually dies, and the next lateral bud continues the axis. There is extensive vegetative propagation by suckers. Some sp. *e.g. S. alba* L. are often pollarded, or cut off at a height of 8 feet or so; from the callus formed upon the wounds new shoots spring, and thus the 'crown' of shoots is produced (p. 156). Among the Brit. sp. are *S. herbacea* L., the dwarf or arctic willow, a creeping alpine and arctic form (p. 183), and *S. lanata* L. &c. alpine forms with very woolly leaves. The flrs. contain honey, and as they appear in early spring, before the leaves, and when they have but few competitors, they receive a great many visits from insects, especially from bees. *S. viminalis* L. is the osier, whose twigs are used in making baskets &c. *S. babylonica* L. is the weeping willow. [See p. 174.]

Salpiglossis Ruiz et Pav. Solanaceae (V). 8 sp. S. Am.

Salsola Linn. Chenopodiaceae (10). 40 sp. chiefly Eur., As., maritime or on salt steppes (p. 169). *S. Kali* L. (glass-wort) in Brit., a very fleshy plant with leaves ending in spines. A variety *tragus* Moq. of this sp. (Russian thistle) has in recent years become a pest of agriculture in Dakota and other parts of N. Am. (*Bot. Gaz.* 1895, p. 501).

Salvadora Garcin. ex Linn. Salvadoraceae. 2 sp. W. As., Afr. *S.*

persica L. is said to be the mustard of the New Testament. Its leaves taste like mustard.

Salvadoraceae. Dicotyledons (Sympet. Contortae). 3 gen. with 6 sp. As., Afr. Shrubs and trees with opp. entire stip. leaves and racemose infls. Flrs. ☿ or unisexual, regular. K (2—4); C (4—5) or 4—5, with teeth or glands on the inner side; A 4—5, epipetalous or not. Ovary superior, 1—2-loc. with 1—2 erect anatropous ovules in each loc. Fruit a 1-seeded berry or drupe. Seed exalbuminous. *Genera:* Azima, Dobera, Salvadora. The relationships are doubtful, for we do not know if the polypetaly of A. and D. is original or secondary. If the former, the order must perhaps be placed near Celastraceae. Benth.-Hooker place it in Gentianales, Warming in Contortae.

Salvia (Tourn.) Linn. Labiatae (VI. 6). 500 sp. trop. and temp. *S. Verbenaca* L. (sage) and *S. pratensis* L. (clary) in Brit. The sta. are reduced to 2 (the anterior), each of which has a sort of T-shape, the connective of the versatile anther being greatly elongated. The stalks of the sta. stand up close together across the mouth of the flr., and a bee, in pushing its head or tongue down towards the honey, comes into contact with the inner end of the anther, and raising it causes the outer to descend upon its back and to rub it with pollen. In the lower forms of S. both ends of the lever bear fertile anthers; but in all the higher forms the useless half-anther at the inner end is aborted, and the outer half of the connective is much longer than the inner (compare *S. officinalis* with *S. pratensis*). The flr. is protandrous, and in the later stage the style bends downwards and places the stigma in a position to be touched first by an entering insect. Some sp. have coloured bracts at the top of the infl., adding to its conspicuousness. *S. officinalis* L. (Medit.) is the garden sage.

Salvinia (Mich.) Schreb. Salviniaceae. 5 sp. trop. and warm temp., of which *S. natans* Hoffm. is best known. The plant floats freely on the water; at each node is a whorl of three leaves, and the whorls alternate with one another. There are two floating leaves derived from the upper half of a segment of the apical cell (see order), and a submerged leaf derived from the lower. There are no roots, their function being performed by the finely divided submerged leaves (see p. 160, and compare Trapa, Ranunculus, Cabomba). The sporocarps are borne several together as outgrowths from the base of a submerged leaf. The microspores germinate inside the sporangium, the prothalli emerging through its wall as fine tubes, at the end of which the antheridia form.

Salviniaceae. Filicineae Leptosporangiatae (Heterosporous). A small family, composed of two genera, Salvinia and Azolla, comprising about 9 sp., trop. and temp. They are water plants, with a stem floating upon the water, and growing by a two-sided apical cell (3-sided in the young embryo, as in other Filicineae). A dorsiventral construction thus arises; segments are cut off right and left from the two-sided apical cell, and the first division of each of these segments divides it into a dorsal and a ventral half. In S. the dorsal halves give rise to the floating, the ventral to the submerged leaves; in A. the former give rise to the leaves, the latter to the branches and roots. The sporangia are grouped into sori; the sorus is enclosed in a highly developed indusium, forming a sporocarp. Each sorus contains only one kind of sporangium (micro- or mega-sporangia). The sporocarp is an outgrowth of a leaf,—in S. of a submerged leaf, in A. of the ventral lobe of an ordinary leaf. The spore is covered with an *epispore*, consisting of hardened frothy mucilage. It sinks, when set free from the sporangium. On germination the microspore forms a rudimentary ♂ prothallus consisting of one (? more) vegetative cell and an antheridium. The megaspore forms a ♀ prothallus, which remains enclosed in the burst spore. This prothallus has two parts, an upper small-celled green part on which are borne the archegonia, and a lower colourless part (of one or more large cells), in which reserves are stored up for the use of the young plant which will be formed from a fertilised ovum (compare Selaginella and Phanerogams).

Sambucus (Tourn.) Linn. Caprifoliaceae (I). 20 sp. N. temp., S. Am., As. to Austr. *S. nigra* L. is the common elder. *S. Ebulus* L. is also found in Brit. The genus differs from the rest of the order in having compound leaves and extrorse anthers. It also possesses well-marked stipules. There has of late been some discussion about the proper position to be assigned to it. Fritsch (*Nat. Pfl.*) assigns it a separate sub-order. Later he proposed (*Bot. Cent.* 50, 1892, p. 137, 168) to fuse Caprifoliaceae with Rubiaceae, but to add S. itself to Valerianaceae. Höck (*Bot. Cent.* 50, 1892, p. 233) thinks this hardly justifiable and proposes to erect a new family, *Sambucaceae*, forming a link between the cohorts Rubiales and Aggregatae. He gives a scheme showing probable relationships of these orders to the other Sympetalae with inferior ovary, and to Umbelliferae &c. A wine is prepared from elder berries.

Samolus (Tourn.) Linn. Primulaceae (II). 8 sp.; *S. Valerandi* L., the brook-weed, is cosmop., the rest S. Hemisph. The whole plant dies down in autumn, but young shoots form in summer and take root, so that the parent plant is replaced. The bracts of the flrs. are 'adnate' to the axes, so as to look like solitary bracteoles; this is due to a process of growth carrying both bract and axis up together (see p. 30 and cf. Solanaceae).

Samyda Linn. Flacourtiaceae. 4 sp. W. Ind., Mexico.

Samydaceae (Benth.-Hooker). An order in cohort Passiflorales, comprising the genera Samyda, Casearia, &c.; placed in Flacourtiaceae by Engler.

Sanguinaria Dill. ex Linn. Papaveraceae (II). 1 sp. Atlantic N. Am., *S. canadensis* L., the blood-root. It has a thick rhizome giving off annually one leaf and a 1-flowered scape. The rhizome is used in medicine.

Sanguisorba Rupp. ex Linn. = Poterium Linn. *S. minor* Scop. = *P. Sanguisorba*; *S. officinalis* L. = *P. officinale.*

Sanicula (Tourn.) Linn. Umbelliferae (3). 12 sp. Eur., As., Afr., Am. *S. europaea* L. (sanicle) in Brit. Flrs. in cymose umbels, themselves arranged in dichasia. Fruit hooked for animal-distribution.

Sansevieria Thunb. Liliaceae (VIII). 10 sp. trop. Afr. to E. Ind. Xerophytes with fleshy leaves. *S. zeylanica* Willd. is largely cultivated in the tropics as a source of fibre (bow-string hemp).

Santalaceae. Dicotyledons (Archichl. Santalales). 26 gen. with 150 sp. of semi-parasitic shrubs, trees and herbs, resembling the Loranthaceae in many ways. Some are stem-parasites like mistletoe, others root-parasites like Rhinanthus (e.g. Thesium). [See *Nat. Pfl.* for details of anatomy &c. of the suckers.] The total infl. may be a raceme, spike, head, &c., but often, instead of the single flr. in each axil, there is a little cyme of 3, as in Loranthaceae. The flrs. are ☿ or unisexual. They have a perigynous or epigynous disc and a simple perianth (sepaloid or petaloid). The sta. are equal in number to, and inserted on, the perianth-leaves. Ovary inferior, 1-loc., with a central placenta bearing 1—3 ovules. Fruit a nut or drupe. Seed 1, with no testa, and with much endosperm. [For details of embryo-sac and other interesting features see Hieronymus, in *Nat. Pfl.*] *Chief genera:* Santalum, Thesium. Placed in Achlamydosporeae by Benth.-Hooker, who unite Grubbiaceae and Myzodendraceae to S.; in Hysterophyta by Warming.

Santalales. The 7th cohort of Archichlamydeae (p. 127).

Santalum Linn. Santalaceae. 8 sp. E. Ind. Parasitic trees. *S. album* L. furnishes the true sandal-wood (yellow or white).

Santolina Tourn. ex Linn. Compositae (VII). 8 sp. South-west Eur. *S. Chamaecyparissus* L. is officinal.

Sanvitalia Gualt. Compositae (V). 8 sp. Am.

Sapindaceae. Dicotyledons (Archichl. Sapindales). About 120 gen. with 1000 sp. trop. and subtrop. 5 gen. (Serjania, Paullinia, &c.) with 300 sp. are lianes, the rest erect trees or shrubs. The lianes climb by aid of tendrils, which are metamorphosed infl.-axes and are usually branched or sometimes watch-spring-like (p. 172); their stems often show peculiar internal anatomy. Leaves alt., stip. in the climbing sp., usually compound, pinnate; in the climbing sp. there is usually a true terminal leaflet, but not in the erect sp.; in these one of the last pair of leaflets often becomes terminal, so that the leaf is asymmetric. The tissues of the plants usually contain resinous or latex-like secretions in special cells. The infl. is cymose, usually a cincinnus, with bracts and bracteoles.

Flr. unisexual (the sta. are apparently well developed in the ♀ so that it is easily mistaken for ☿, but the pollen is useless, and the anthers do not open), generally monœcious, regular or often obliquely zygomorphic, 5- or 4-merous. K usually 5, rarely (5), imbricate or rarely valvate or open, sometimes apparently 4-merous by union of 2 sepals; C usually 5, imbricate, with well-marked disc between it and the sta.; A usually 5 + 5 in one whorl, often with 2 absent, more rarely 5, 4. or ∞, inserted within or rarely upon the disc round the rudimentary ovary. G in ♀ flr. usually (3), 3-loc. with terminal style; ovules usually 1 in each loc., ascending, with ventral raphe. Fruit a capsule, nut, berry, drupe, schizocarp, or samara, usually large, often red; seed often arillate, with no endosperm; embryo usually curved.

Many S. are of economic value; several yield valuable timber; Nephelium, Litchi, and others furnish edible fruits.

Classification and chief genera (after Radlkofer):

I. *EUSAPINDACEAE* (ovules solitary in loculi, erect or ascending, with micropyle downwards): Serjania, Paullinia, Sapindus, Talisia, Schleichera, Litchi, Nephelium, Pappea, Cupania, Blighia.

II. *DYSSAPINDACEAE* (ovules usually 2 or several in each loc., in the first case erect or pendulous, in the second horizontal, rarely 1 pendulous with micropyle upwards): Koelreuteria, Dodonaea.

[Benth.-Hooker unite to S. the Aceraceae, Staphyleaceae and Hippocastanaceae, placing the order in Sapindales; Warming places it in Aesculinae.]

Sapindales. The 16th cohort (Engler) of Archichlamydeae (p. 129). The 10th cohort (Benth.-Hooker) of Polypetalae (p. 133).

Sapindus Tourn. ex Linn. Sapindaceae (I). 11 sp. trop. and subtrop. exc. Afr. and Austr. The berries of *S. Saponaria* L. (Am.) form a lather with water, and are sometimes used as soap; they contain saponin.

Sapium P. Br. Euphorbiaceae (A. II. 7). 25 sp. trop. Seeds of *S. sebiferum* Roxb., the tallow-tree of China, are coated with fat; they also yield an oil by pressure.

Saponaria Linn. Caryophyllaceae (I. 2). 20 sp. N. temp., chiefly Medit. *S. officinalis* L. (soapwort) in Brit. Its leaves lather if rubbed with water. Flrs. protandrous, butterfly-visited.

Sapota Plum. ex Mill. = Achras Linn.

Sapotaceae. Dicotyledons (Sympet. Ebenales). 31 gen. with 370 sp. in all trop. lands. They are mostly trees with entire leathery leaves, sometimes stipulate. They are commonly hairy with 2-shanked hairs, and contain secretory passages in pith, cortex and leaves. The flrs. are solitary or in cymose bunches in the leaf-axils or on old stems, bracteolate, ☿, regular or not. K 2 + 2, 3 + 3, 4 + 4, or 5; C usually equal in number to sepals, and alternating with the calyx as a whole, as in Cruciferae, rarely in 2 whorls. In *Mimusopeae* the petals have dorsal appendages like themselves, giving the appearance of more than one whorl. Sta. in 2 or 3 whorls, but frequently the outer ones are staminodial or absent; anthers commonly extrorse. G superior, syncarpous, multiloc.; cpls. as many or twice as many as the number of sta. in a whorl, or more; ovules inserted at base of axile placenta, one in each loc., anatropous with micropyle facing downwards; style simple. Fruit a berry, the flesh sometimes sclerenchymatous near the surface. Seeds few or one, usually albuminous; endosperm oily; testa hard and rich in tannin.

Many S. furnish useful products, especially gutta-percha; see the genera below.

Classification and chief genera (after Engler):

I. *Palaquieae* (petals without appendages): Bassia, Payena, Palaquium, Achras, Butyrospermum, Sideroxylon, Chrysophyllum.

II. *Mimusopeae* (petals with appendages—see above): Mimusops.

[Placed in Ebenales by Benth.-Hooker, in Diospyrinae by Warming.]

Sarcocalyx Walp. = Aspalathus Linn.

Sarcocapnos DC. Papaveraceae (III). 3 sp. Medit.

Sarcocaulon Sweet. Geraniaceae. 4 sp. S. Afr. Xerophytes with fleshy stems. When the leaf falls it leaves behind the base of the petiole which hardens into a thorn (p. 20).

Sarcococca Lindl. Buxaceae. 4 sp. E. Ind., Malaya.

Sarcocolla Linn. Penaeaceae. 4 sp. Cape Colony.

Sarcodes Torr. Pyrolaceae. 1 sp. California.

Sarcoglottis Presl = Spiranthes Rich.

Sarcostemma R. Br. Asclepiadaceae (II. 2). 12 sp. Afr., E. Ind., Austr. Leafless xerophytes with slightly fleshy stems.

Sarothamnus Wimm. = Cytisus Linn.

Sarracenia Linn. Sarraceniaceae. 6 sp. Atlantic N. Am. (side-saddle flowers), in sunny marshy places. Low herbs with rosettes of radical leaves; each leaf is represented by a long narrow pitcher with a flat green wing of tissue on the ventral side, serving chiefly for assimilation. The general structure of the pitcher is closely similar to that found in Nepenthes; it has a fixed lid projecting over the mouth, and the lip is usually turned down inwards. The mouth of the pitcher bears numerous honey-glands; below these comes the 'slide-zone,' then the zone of hairs (cf. Nepenthes), and at the bottom is water in which the insects are drowned (see p. 178). The pitchers are often brightly coloured. It should be noted that in S. the entire leaf is transformed into a pitcher, while in Nepenthes it is only part of the leaf, and in Cephalotus only certain leaves. [See literature quoted on p. 177.]

Sarraceniaceae. Dicotyledons (Archichl. Sarraceniales). 3 gen. with 8 sp. Am. Insectivorous pitcher-plants (see gen.) with rosettes of radical leaves and ☿ regular flrs. K 9—8—5, spiral, if >5 the outer 3 small; C as many as inner sepals and alt. with them, or 0; A ∞; $\underline{G}$ (6—5—3) with ∞ anatropous ovules on inrolled cpl.-walls.

Loculicidal capsule with ∞ seeds; endosperm fleshy. *Genera:* Heliamphora (raceme; ovary 3-loc.), Sarracenia (flr. solitary; ovary 5-loc., the top of the pitcher simple), Darlingtonia (ditto, but the top of the pitcher is fish-tail-shaped). Placed in Parietales by Benth.-Hooker, in Cistiflorae by Warming.

Sarraceniales. The 13th cohort of Dicotyledons (p. 128).

Sassafras Linn. Lauraceae. 1 sp. Canada to Florida, *S. officinale* Nees et Eberm. (*Laurus Sassafras* L.). The wood and bark yield oil of sassafras, used in medicine.

Satureia Linn. Labiatae (VI. 11.) 130 sp., trop., subtrop. and warm temperate regions. The flrs. are gynodioecious. *S. hortensis* L. and *S. montana* L., the summer and winter savories respectively, are often grown as flavouring herbs.

Satyrium Linn. Orchidaceae (3). 60 sp. Cape Col., trop. Afr., E. Ind. The flr. is not twisted, so that the labellum stands uppermost; it is prolonged backwards into two spurs. The actual summit of the column is occupied by the stigma, the anther being bent round at right angles to it.

Saurauia Willd. Dilleniaceae. 60 sp. trop. As., Am.

Sauromatum Schott. Araceae (VII). 5 sp. trop. Afr., Himal. Leaves pedate (cymosely branched).

Saururaceae. Dicotyledons (Archichl. Piperales). 3 gen. with 4 sp. E. As. and N. Am. Herbaceous plants with ☿ flrs., which are apparently primitively naked (see p. 75). Sta. 6 or fewer; cpls. 3—4 or (3—4), in the latter case with parietal placentae. Ovules orthotropous. Seeds with endo- and peri-sperm. *Chief genera:* Saururus, Houttuynia. United to Piperaceae by Benth.-Hooker.

Saururus Plum. ex Linn. Saururaceae. 1 sp. Japan to Philippine Is., 1 in U. S. Bog plants with spikes of flrs., the bract usually adnate to the axis of its flr.

Saussurea DC. Compositae (XI). 125 sp. N. temp. *S. alpina* DC. is an alpine sp. in Brit., with hairy leaves (p. 182); its flrs. are blue, with sweet scent (the latter unusual in the order). Many flrs. have 3 cpls.

Sauvagesia Linn. Ochnaceae. 10 sp. Brazil and 1 in all trop. regions. There are 5 fertile sta., surrounded by ∞ staminodes. Cpls. 3. This genus and a few others are sometimes formed into a separate order, or placed (e.g. by Bentham and Hooker) in Violaceae.

Savia Willd. Euphorbiaceae (A. I. 1) 4 sp. W. Ind.

Saxegothaea Lindl. Coniferae (Taxac. 3; see C. for genus characters). 1 sp. Andes of Patagonia. Fruit a many-seeded 'berry' like that of Juniperus.

Saxifraga Linn. Saxifragaceae (I). 200 sp. N. temp., Arctic, Andes, chiefly alpine (p. 180). 13 sp. in Brit. (saxifrage). Most sp. show xerophytic characters, such as tufted growth, close packing of leaves (especially well shown in *S. oppositifolia* L.), succulence, hairiness, &c.

Many sp. are vegetatively propagated by offsets, or (e.g. *S. granulata* L.) by bulbils produced in the lower leaf-axils. Many exhibit chalk-glands at the tips or edges of the leaves (e.g. *S. oppositifolia* at the tip); these are water-pores (p. 114) with nectary-like tissue beneath, secreting water containing chalk in solution. As the water evaporates, the chalk forms an incrustation. The flrs. are usually in dichasial cymes with a cincinnus tendency. Every stage occurs in various sp. from hypogyny to epigyny (p. 71). The honey is only partially concealed, and the flrs. are visited by a miscellaneous lot of insects. Most sp. are protandrous. A few, e.g. *S. sarmentosa* Linn. f., have zygomorphic flrs. [For leaf-forms, see Jungner in *Bot. Notiser*, 1894—1895, reviewed in *Bot. Centr.* 62, 1895, p. 244.]

Saxifragaceae. Dicotyledons (Archichl. Rosales). 70 gen. with 600 sp. cosmop., chiefly temp. Most are perennial herbs, a few shrubs or trees, with usually alt., rarely stip. leaves. Many are alpine and arctic forms of xerophytic habit (p. 180). The infl. is of various kinds, both racemose and cymose.

Flr. usually ☿, regular, cyclic, 5-merous (except cpls.). The receptacle is flat or hollowed to various depths, so that the sta. and perianth may be peri- or epi-gynous. K usually 5; C 5, imbricate or valvate, sometimes (5) or 0; A usually 5 + 5, obdiplostemonous; cpls. rarely free and as many as petals, usually fewer and joined below, often 2; placentae parietal or axile, with several rows of anatropous ovules; styles as many as cpls. The flrs. are mostly protandrous. Fruit a capsule or berry. Seed with rich endosperm round a small embryo.

The S. are of little economic importance; Ribes yields valuable fruit. Many are favourites in horticulture, e.g. Saxifraga, Francoa, Philadelphus, Deutzia, Hydrangea, Escallonia.

Classification and chief genera:

I. *SAXIFRAGOIDEAE* (herbs of various habit; leaves alt.; flrs. with 5- or rarely 4-merous perianth; cpls. usually 2; ovary hypo- or epi-gynous, 1- or 2-loc.): Saxifraga, Tellima, Chrysosplenium, Parnassia.

II. *FRANCOIDEAE* (perennial herbs with radical leaves and flrs. in spikes or racemes on naked scapes; flr. 4-merous; ovary 4-loc.): Francoa.

III. *HYDRANGEOIDEAE* (shrubs or trees; leaves usually opp., simple; perianth usually 5-merous; sta. epigynous; ovary 3—5-loc.): Philadelphus, Deutzia, Hydrangea.

IV. *PTEROSTEMONOIDEAE* (shrubs with alt. stip. simple leaves; sta. 10; ovary inferior, 5-loc; ovules 4—6, on axile placentae): Pterostemon.

V. *ESCALLONIOIDEAE* (shrubs or trees, rarely herbs; with simple alt. exstip. often leathery and gland-dotted leaves; sta. = petals; ovary superior to inferior; ovules ∞): Brexia, Escallonia.

VI. *RIBESIOIDEAE* (shrubs with alt. simple exstip. leaves and racemes of flrs.; ovary inferior, 1-loc. with 2 parietal placentae; berry): Ribes.

VII. *BAUEROIDEAE* (shrubs with opp. 3-foliate exstip. leaves and simple axillary flrs.; ovary semi-inferior with 2 parietal placentae; loculicidal capsule): Bauera.

[Placed in Rosales by Benth.-Hooker, in Saxifraginae by Warming.]

Saxifrageae (Benth.-Hooker) = Saxifragaceae.

Saxifraginae (Warming). The 18th cohort of Choripetalae (p. 137).

Scabiosa (Tourn.) Linn. (incl. *Knautia* Linn., *Pterocephalus* Vaill., *Succisa* Neck.). Dipsacaceae. 86 sp. Eur., As., Afr., esp. Medit.; 3 in Brit., of which *S.* (*K.*) *arvensis* L. (scabious) and *S. Succisa* L. (devil's-bit scabious) are common. The former has a large head of flrs.; the corolla of these is drawn out upon the outer side (cf. Compositae), and this the more the further they are from the centre of the head. Honey is secreted by the upper surface of the ovary, and protected from rain by hairs in the tube. The sta. are ripe first, while the style with immature stigmas is quite enclosed in the corolla; later the sta. wither and the style occupies their place. The stigmas of the various flowers upon the head ripen nearly simultaneously.

Scaevola Linn. Goodeniaceae. 60 sp. Austr., Polynes., coasts of trop. Afr., As., Am. *S. Koenigii* Vahl furnishes a kind of rice paper; its pith is squeezed flat like that of Fatsia.

Scandix Tourn. ex Linn. Umbelliferae (5). 12 sp. Eur., As., N. Afr. *S. Pecten-Veneris* L. (Venus' comb) in Brit. The ripe mericarps separate with a violent jerk.

Scheuchzeria Linn. Juncaginaceae. 1 sp., *S. palustris* L., N. temp and arctic, incl. Brit.; a marsh plant.

Schinus Linn. Anacardiaceae (III). 4 sp. Mexico to Argentina. *S. Molle* L. yields American mastic (resin).

Schismatoglottis Zoll. et Mor. Araceae (V). 10 sp. Malaya. At the top of the spadix, above the ♂ flrs., are sterile flrs. consisting of staminodes.

Schivereckia Andrz. = Alyssum Tourn.

Schizaea Sm. Schizaeaceae. 16 sp. trop. and subtrop. The sporangia form a double row on the lower surface of each of the reduced fertile pinnae.

Schizaeaceae. Filicineae Leptosporangiatae (Homosporous). 5 gen. with 70 sp., chiefly trop. Am.; a few subtrop. or temp. They are mostly small ferns with but little stem. Lygodium is a curious leaf-climber. As in Osmunda, the sporangia are borne (exc. in Mohria) on special pinnae of the leaf, distinct from the ordinary vegetative pinnae. The sporangia are sessile, usually without indusium; at the apex is a cap-like annulus, and the sporangium dehisces longitudinally. *Chief genera:* Schizaea, Aneimia, Lygodium, Mohria.

Schizandra Michx. Magnoliaceae (2). 7 sp. trop. and warm temp. As.;

S. coccinea Michx. in Atlantic N. Am. Climbing shrubs with exstip. leaves and spiral flrs.

Schizanthus Ruiz et Pav. Solanaceae (V). 11 sp. Chili. The flr. is zygomorphic; the stalk is curved, and the two really upper petals form the lower lip which is 3—4-lobed, while the lateral petals are 4-lobed and the lowest petal forms the simple or slightly 2-lobed upper lip. Sta. 4, 2 fertile and 2 staminodial. The flr. has a good general likeness to that of the papilionate Leguminosae (cf. Collinsia), and is fertilised in a very similar way, usually by an explosive movement of its parts (cf. Genista).

Schizopetalon Sims. Cruciferae (III. 12). 5 sp. Chili.

Schizostigma Arn. Rubiaceae (I. 7). 1 sp. Ceylon. Ovary 5—7-loc.

Schizostylis Backh. et Harv. Iridaceae (III). 2 sp. S. Afr. *S. coccinea* Backh. et Harv. is often cultivated for its handsome flrs.

Schkuhria Roth. Compositae (VI). 11 sp. W. Am.

Schlechtendalia Less. Compositae (XII). 1 sp. Brazil. A plant of very unusual habit (for this order), and with peculiar anatomy (see *Ber. D. Bot. Ges.* II. 1884, p. 100).

Schleichera Willd. Sapindaceae (I). 1 sp. trop. As., *S. trijuga* Willd. It furnishes a useful timber; the aril of the seed is edible, and an oil is expressed from the seed itself.

Schoenocaulon A. Gray. Liliaceae (I). 5 sp. Am. Veratrin is made from the seeds.

Schoenus Linn. Cyperaceae (II). 70 sp. Austr., a few in Afr., Am., Eur.; *S. nigricans* L. in Brit.

Schollera Roth = Vaccinium Linn.

Schomburgkia Lindl. Orchidaceae (13). 12 sp. trop. Am.

Schotia Jacq. (*Theodora* Medic.). Leguminosae (II. 3). 6 sp. trop. and S. Afr.

Schubertia Mart. = Araujia Brot.

Sciadopitys Sieb. et Zucc. Coniferae (Arauc. I c; see C. for genus characters). 1 sp. Japan, *S. verticillata* Sieb. et Zucc., the parasol-pine or umbrella-fir, planted round the temples. The short shoots are crowded together at the ends of the annual long shoots. Each short shoot resembles that of Pinus except that the two green needle-leaves are 'fused' together into a single needle grooved down the centre, so that at first glance in S. the short shoots seem to be whorls of ordinary leaves at the tip of each year's growth. The cones take two years to ripen. The wood is useful for waterworks &c.

Scilla Linn. Liliaceae (V). 80 sp. Old World temp. *S. festalis* Salisb. (*S. nutans* Sm.), wild hyacinth or English bluebell, and others in Brit. Bulbous plants with racemes of flrs.

Scirpus (Tourn.) Linn. Cyperaceae (I). 200 sp. cosmop. in bogs and marshes; 15 in Brit. The stem is usually erect and angular, bearing 3 ranks of leaves reduced to sheaths, and performs the work of assimilation. Its base often gives rise to creeping rhizomes or to shoots ending in tubers like potatoes. The racemose many-flowered spikelets are aggregated into a terminal tuft. The flr. is ☿, and has 6 perianth-scales in two whorls; in many sp. it is protogynous; in all it is wind-pollinated. *S. lacustris* L., sometimes termed the bulrush, is used for matting, chair-seats, &c.

Scitamineae. The 9th cohort (Engler) of Monocotyledons (p. 126). An order (Benth.-Hooker) in series Epigynae, including Musaceae, Marantaceae, Cannaceae, and Zingiberaceae of Engler. The 6th cohort (Warming) of Monocotyledons (p. 137).

Scleranthaceae or Illecebraceae. See Caryophyllaceae.

Scleranthus Linn. Caryophyllaceae (II. 6). 10 sp. Eur., As., Afr.; *S. annuus* L. (Knawel) and another in Brit. Flrs. apetalous, self-fertilising.

Scleria Berg. Cyperaceae (II). 100 sp. trop. and warm temp.

Sclerochloa Beauv. Gramineae (X). 1 sp. Eur., As.

Scoliopus Torr. Liliaceae (VII). 2 sp. West N. Am.

Scolopendrium Sm. Polypodiaceae. 10 sp. trop. and temp., esp. N. Hemisphere. *S. vulgare* Sm. (hart's tongue fern) in Brit.

Scolymus Tourn. ex Linn. Compositae (XIII). 3 sp. Medit.

Scopolia Jacq. Solanaceae (II). 4 sp. Eur., As.

Scorpiurus Linn. Leguminosae (III. 7). 6 sp. Medit. The pod is twisted and indehiscent; often it looks like a caterpillar, and it has been suggested that birds are deceived by this and carry it to a distance before discovering the mistake.

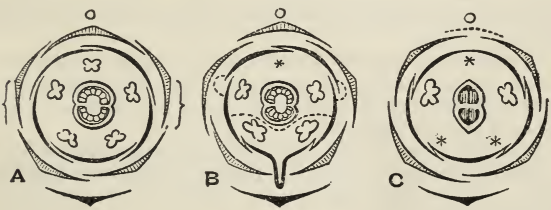
Scorzonera (Tourn.) Linn. Compositae (XIII). 100 sp. N. temp. Old World. Like Taraxacum. The roots of *S. hispanica* L. and others are eaten as vegetables.

Scrophularia Tourn. ex Linn. Scrophulariaceae (II. 6). 115 sp. N. temp.; 3 in Brit.; *S. aquatica* L. and *S. nodosa* L., the fig-worts, are common. Perennial herbs with opp. leaves, which on the lateral twigs are commonly anisophyllous (p. 47). The flrs. are in tall infls. whose primary branching is racemose; the lateral shoots are dichasial. The flr. has the sta. and style arranged along the lower lip of the corolla, instead of the upper, as is usually the case in such flrs. Correlated with this is the fact that the posterior sta., usually absent in the order, is represented by a staminode, as it is not in the way of insects entering the flr. (it is entirely aborted in flrs. which have the essential organs under the upper lip). The flr. is markedly protogynous, and is largely visited by wasps and but rarely by other insects. The peculiar brown colour may perhaps be due to the selection of wasps; but there are so few wasp-flowers that it is impossible to draw any conclusions upon the subject (see Cotoneaster and Epipactis).

Scrophulariaceae. Dicotyledons (Sympet. Tubiflorae). About 180 gen. with 2000 sp., cosmop. Most are herbs and undershrubs, a few shrubs or trees (e.g. Paulownia), with alt., opp., or whorled exstip. leaves. Many exhibit interesting features in the vegetative organs.

Several are climbers (e.g. Maurandia, Rhodochiton, &c.). The Veronicas of N. Z. are interesting xerophytes with remarkable resemblance in habit to certain Coniferae. A considerable number of sp. in tribes 11 and 12 (below), e.g. Euphrasia, Bartsia, Pedicularis &c., are semi-parasitic (p. 176). They mostly grow in swampy grassland and are parasitic by their roots upon the roots of the grasses. Suckers are formed at the points of contact. "The formation of the suckers occurs in spring; the absorption of organic food by their means from living parts of plants lasts into the summer; at this period the haustoria contain but little starch. In late summer and autumn an absorption of organic compounds from the dead parts of the host takes place. At this period, and later, the haustoria function as places for storage of reserve-materials" (von Wettstein). The plants possess green leaves of their own, and so are able to assimilate.

The infl. may be racemose or cymose. In the former case it is usually a spike or raceme, axillary or terminal (every variety may be



Floral diagrams of A, *Verbascum nigrum*, B, *Linaria vulgaris*, C, *Veronica Chamaedrys*; after Eichler.

found in sp. of Veronica). Solitary axillary flrs. occur in many S., e.g. Linaria. The cymose infls. are usually dichasia, often united into complex corymbs &c. Bracts and bracteoles are usually present. In Castilleja the upper leaves and bracts are brightly coloured.

The flr. is ☿, zygomorphic, sometimes nearly regular (Verbascum &c.), and shows considerable variety in structure, as is illustrated by the floral diagrams given. The bulk of the order show the Linaria type. K (5), of various aestivations; C (5), median-zygomorphic, often 2-lipped; A 4 (sometimes 2), didynamous, epipetalous, the posterior sta. sometimes represented by a staminode (e.g. in Scrophularia and Pentstemon). Verbascum and its allies have an actinomorphic corolla and 5 sta.; Veronica (q.v.) shows 4 sepals (the posterior one of the typical 5 being absent), 4 petals (the posterior pair of the 5 united), and 2 sta., the corolla being rotate in form. Other variations occur in the *Selagineae* &c. Below the ovary is a honey-secreting disc. G (2), medianly placed (not obliquely as in Solanaceae), 2-loc., with axile placentae. Ovules usually ∞, less commonly few (e.g. Veronica &c.), anatropous. Style simple or bilobed. Fruit surrounded below by the persistent calyx, usually a capsule (dehiscent in various ways) or a berry. Seeds usually numerous, small, with endosperm. Embryo straight or slightly curved.

Most of the order have flrs. more or less adapted to insect-visits. Müller divides them into 4 types: (1) the Verbascum or Veronica type (see genera) with open flr. and short tube (bees and flies), (2) the Scrophularia type (wasps), (3) the Digitalis and Linaria type with long wide tubes and the essential organs so placed as to touch the back of the insect (bees), and (4) the Euphrasia type or 'loose-pollen' flr. (p. 98), where the pollen is loose and powdery, and the anthers (protected by the upper lip of the flr.) are provided with spines &c., so that they may be shaken upon the entrance of the insect, which thus receives a shower of pollen on its head. The flrs. are seldom markedly dichogamous, but the stigma usually projects beyond the sta. so as to be first touched by a visitor. Most of the flrs. are capable of self-fertilisation in default of insect-visits. For further details see genera.

In Linaria &c. (q.v.) there sometimes appears a terminal flr. to the raceme, and this exhibits the phenomenon of *peloria*, having a symmetrical corolla with spurs to all the petals (cf. Ruta, or compare Aquilegia with Delphinium).

A number of the S. are or have been officinal e.g. Digitalis; most of them are poisonous. Many are favourite garden and greenhouse plants, e.g. Calceolaria, Mimulus, Pentstemon, Antirrhinum, Linaria, Veronica, Collinsia &c.

Classification and chief genera (after von Wettstein):

A. The two posterior corolla-teeth (or the upper lip) cover the lateral teeth in bud.

I. *PSEUDOSOLANEAE* (all leaves usually alt.; 5 sta. often present):

1. *Verbasceae* (corolla with very short tube or none, rotate or shortly campanulate): Verbascum, Celsia.

2. *Aptosimeae* (corolla with long tube): Aptosimum.

II. *ANTIRRHINOIDEAE* (lower leaves at least opp.; the 5th sta. wanting or staminodial):

α. Corolla 2-lipped; lower lip concave, bladder-like.

4. *Calceolarieae:* Calceolaria.

β. Corolla almost actinomorphic, or 2-lipped with flat or convex lips.

3. *Hemimerideae* (dehiscent capsule; corolla spurred or saccate at base, with no tube): Alonsoa.

5. *Antirrhineae* (as 3, but with tube): Linaria, Antirrhinum, Maurandia, Rhodochiton.

6. *Cheloneae* (dehiscent capsule or many-seeded berry; corolla not spurred or saccate; infl. cymose, compound): Russelia, Wightia, Collinsia, Scrophularia, Chelone, Pentstemon, Paulownia.
7. *Manuleae* (dehiscent capsule; corolla as in 6; infl. not cymose, usually simple; anthers finally 1-loc.): Zaluzianskia, Lyperia.
8. *Gratioleae* (as 7, but anthers finally 2-loc.): Mimulus, Gratiola, Torenia.
9. *Selagineae* (fruit a drupe or an indehiscent few-seeded capsule): Hebenstretia, Selago.

B. The two posterior teeth (or the upper lip) of the corolla covered in bud by one or both of the lateral teeth.

III. *RHINANTHOIDEAE.*

a. Corolla-teeth all flat and divergent, or the 2 upper erect.

10. *Digitaleae* (anther-loc. finally united at tip; the 2 upper corolla-lobes often erect; not parasitic): Veronica, Digitalis.
11. *Gerardieae* (anther-loc. always separate, one often reduced; corolla-lobes all flat, divergent; often parasitic): Gerardia.

b. The 2 upper corolla-teeth form a helmet-like upper lip. Often parasitic.

12. *Rhinantheae:* Castilleja, Melampyrum, Tozzia, Euphrasia, Bartsia, Pedicularis, Rhinanthus.

[Benth.-Hooker exclude from S. the 9th tribe, which they unite with Globulariaceae to form a separate order Selagineae, placed in Lamiales; the rest of the order they place in Personales. Warming following Eichler places the order in Personatae, excluding the *Selagineae*, which are placed as a separate order (Selaginaceae, not united to Globulariaceae), in Nuculiferae.]

Scrophularineae (Benth.-Hooker) = Scrophulariaceae.

Scutellaria Riv. ex Linn. Labiatae (IV). 180 sp. cosmop. exc. S. Afr. 2 in Brit., *S. galericulata* L. and *S. minor* Huds. (skull-cap).

Scuticaria Lindl. Orchidaceae (27). 2 sp. trop. Am. Epiphytes, with no tubers, but long pendulous fleshy cylindrical stems.

Scybalium Schott et Endl. Balanophoraceae. 4 sp. trop. Am.

Seaforthia R. Br. = Ptychosperma Labill.

Secale (Tourn.) Linn. Gramineae (XII). 2 sp. Medit., Eur., As. *S. cereale* L., the rye, is largely cultivated in Germany, Russia, &c., as a cereal, forming a staple food.

Secamone R. Br. Asclepiadaceae (II. 3). 24 sp. trop. Afr., As., Austr.

Sechium P. Br. Cucurbitaceae (IV). 1 sp. trop. Am., *S. edule* Sw., largely cultivated for its edible fruit (choco), containing one enormous seed which germinates within the fruit.

Securidaca Linn. Polygalaceae. 30 sp. trop., except Austr.

Securigera DC. Leguminosae (III. 5). 1 sp. Medit.

Securinega Comm. ex Juss. Euphorbiaceae (A. I. 1). 10 sp. temp. and subtrop.

Sedum Tourn. ex Linn. Crassulaceae. 140 sp. N. temp., 1 in Peru; 9 in Brit., incl. *S. Telephium* L. (orpine or livelong), *S. Rhodiola* DC. (rose-root), *S. anglicum* Huds. and *S. acre* L. (stonecrop or wall-pepper). Fleshy-leaved xerophytes.

Seguieria Loefl. Phytolaccaceae. 8 sp. S. Am. Leaves leathery; stipules thorny. The plants have a powerful odour of garlic. Cpl. 1. The fruit is a samara, closely resembling one half of that of Acer or many Malpighiaceae.

Selagineae (Benth.-Hooker). See Scrophulariaceae.

Selaginella Spring. The only genus of Selaginellaceae. 350 sp. chiefly trop. A few are temp. e.g. *S. selaginoides* Link on boggy hill sides in Brit. Most of the sp. live in damp places, especially in forests, but there are a few xerophytes. The embryo is provided with a suspensor, and grows directly into the leafy plant, which shows a habit very similar to that of Lycopodium—much-branched stem, often creeping, bearing roots on the lower side and leaves on the upper, with terminal cones of sporangia. The leaves may be spirally arranged as in most sp. of Lycopodium (e.g. in *S. selaginoides*), or more commonly they form 4 ranks, two outer ones of large, two inner of small leaves, thus giving the stem a dorsiventral structure. The roots in some sp., e.g. *S. Kraussiana* A. Br. and *S. Martensii* Spring, are borne on *rhizophores*, anomalous stem branches developed at the nodes and exhibiting a sort of intermediate structure between stem and root. The sporangia are placed at the bases of the leaves in terminal cones, which exhibit radial symmetry. The mega-sporangia contain 4 large spores and can easily be distinguished by the naked eye from the micro-sporangia. On germination a microspore produces a rudimentary male prothallus bearing an antheridium. The megaspore forms a female prothallus, which remains enclosed in the burst spore, and has an upper small-celled green portion and a lower large-celled storage portion as in Salviniaceae &c.

S. lepidophylla Spring is a curious little xerophyte which curls up into a ball in the dry season, and may be rolled about by the wind (compare Anastatica).

Selaginellaceae. Lycopodinae (Heterosporous). Only genus Selaginella (q.v.).

Selago Linn. Scrophulariaceae (II. 9). 80 sp. S. Afr., Madagascar.

Selenipedium Rchb. f. Orchidaceae (2). 2 sp. Panama, Guiana. Like Cypripedium, but ovary 3-loc.

Selinum Linn. Umbelliferae (6). 25 sp. N. Hemisph., S. Afr.

Selliera Cav. Goodeniaceae. 2 sp. Austr.

Semecarpus Linn. f. Anacardiaceae (IV). 40 sp. Ceylon to Austr.

Semele Kunth. Liliaceae (VII). 1 sp. Canaries, *S. androgyna* Kunth (*Ruscus androgynus* L.). A climbing shrub with leaf-like phylloclades in the axils of scale-leaves. Flrs. in little cymes (cf. Asparagus) on the edges of the phylloclades. The new shoots rise from the soil, and grow to a considerable length before the lateral branches, bearing the phylloclades, begin to unfold.

Sempervivum Rupp. ex Linn. Crassulaceae. 50 sp. mts. of S. Eur., Himal., Abyss., &c. *S. tectorum* L., the houseleek, often planted on cottages to keep the slates in position, is a xerophyte with fleshy leaves and much vegetative multiplication by offsets.

Senebiera DC. (*Coronopus* Rupp.). Cruciferae (II. 5). 12 sp. subtrop.; one naturalised in Brit. *S. didyma* Pers.

Senecio (Tourn.) Linn. (incl. *Cacalia* Linn., *Cineraria* Linn., *Kleinia* Haw., *Ligularia* Cass., &c.). Compositae (VIII). 1250 sp. cosmop. 9 in Brit. (ragwort, groundsel, &c.). The genus includes plants of the most various habit. Some are climbers, e.g. *S. macroglossus* DC. (S. Afr.), which is remarkably like ivy in habit. Many are xerophytes, some with fleshy leaves, others with fleshy stems, others with hairy or inrolled leaves (cf. Empetrum). The flrs. of *S. vulgaris* L. (groundsel) are regularly self-fertilised, and are very inconspicuous; there are no ray-florets. In *S. Jacobaea* L. (rag-wort) there are ray-florets, and the conspicuous flrs. are largely visited by insects. A very interesting sp. is *S.* (*K.*) *articulatus* Sch. Bip. (S. Afr.), whose fleshy stems easily separate at the joints and grow into new plants.

Sequoia Endl. (*Wellingtonia* Lindl.) Coniferae (Arauc. 1 c.; see C. for genus characters). 2 sp. N.W. Am. *S. gigantea* Lindl. et Gord is the mammoth tree of Calif., discovered in the Sierra Nevada in 1850. Some specimens are more than 300 feet high and 36 feet thick, second only in size to the Eucalyptus; the age of the largest is about 1500 years. In some museums in Brit. there are sections of a tree cut down in 1882 and showing 1335 annual rings. *S. sempervirens* Endl., the redwood, is also a gigantic tree, and is valued for its timber &c.

Serapias Linn. Orchidaceae (3). 5 sp. Medit.

Sericocarpus Nees. Compositae (III). 5 sp. U. S.

Serjania Plum. ex Schum. Sapindaceae (I). 172 sp. trop. and subtrop. Am. Lianes with watch-spring tendrils and stip. leaves. Fruit a 3-winged schizocarp.

Serratula Dill. ex Linn. Compositae (XI). 40 sp. Eur. to Japan. *S. tinctoria* L. (saw-wort) in Brit.; it is diœcious.

Serruria Salisb. Proteaceae (I). 50 sp. S. Afr.

Sesamum Linn. Pedaliaceae. 12 sp. trop. Afr., As. *S. indicum* L. is largely cultivated in India &c. for the oil expressed from its seeds (gingili, gingelly, sesame, &c.).

Sesbania Scop. Leguminosae (III. 6). 20 sp. trop. and subtrop. *S. aculeata* Poir. is a marsh plant, giving off floating roots from the base of the stem, covered with a spongy aerenchyma (p. 161, and cf. Neptunia).

Seseli Linn. Umbelliferae (6). 60 sp. Eur., N. Afr., As. *S. Libanotis* Koch in Brit.

Sesleria Scop. Gramineae (X). 10 sp. Eur., W. As., mostly alpine. *S. coerulea* Arduin. in Brit.

Sesuvium Linn. Aizoaceae (II. 1). 5 sp. trop. and subtrop. Halophytes (p. 169).

Setaria Beauv. Gramineae (V). 12 sp. trop. and warm temp. *S. italica* Beauv. (Italian millet) is cultivated as a cereal in E. As.

Shepherdia Nutt. Elaeagnaceae. 3 sp. N. Am. The receptacle becomes fleshy in fruit. The fruit of *S. argentea* Nutt. (buffalo-berry) is edible.

Sherardia Dill. ex Linn. Rubiaceae (II. 21). 1 sp. Eur. (incl. Brit.), W. As., N. Afr., *S. arvensis* L., the field madder.

Shorea Roxb. Dipterocarpaceae. 87 sp. Ceylon to Philippine Is. *S. robusta* Gaertn. f. (sal) is a most valuable timber tree, with wood like that of teak, and is largely grown in India.

Shortia Torr. et Gray. Diapensiaceae. 1 sp. N. Carolina, 1 sp. Japan (cf. Epigaea).

Sibbaldia Linn. = Potentilla Linn. *S. procumbens* L. = *P. Sibbaldi.*

Sibthorpia Linn. Scrophulariaceae (III. 10). 6 sp. Eur., Medit., Nepal, Andes. *S. europaea* L. (Cornish money-wort) in S. England.

Sicyos Linn. Cucurbitaceae (IV). 30 sp. trop. Am., Polynes., Austr. Some sp. have hooked fruits.

Sida Linn. Malvaceae (II). 70 sp. Am., Austr., 1 Eur., several in all trop. lands.

Sidalcea A. Gray. Malvaceae (II). 10 sp. N.W. Am.

Sideritis Tourn. ex Linn. Labiatae (VI. 1). 45 sp. Medit., Orient.

Sideroxylon (Dill.) Linn. Sapotaceae (I). 80 sp. trop.

Siegesbeckia Linn. Compositae (V). 4 sp. trop. and warm temp. The heads are small, with an involucre of 5 bracts, covered with very sticky glandular hairs. The secretion continues till after the fruit is ripe, and aids in its distribution, the whole head breaking off and clinging to a passing animal.

Silaus Bernh. Umbelliferae (6). 2 sp. Eur., Siberia (1 Brit.).

Silene Linn. Caryophyllaceae (I. 1). 300 sp. N. temp., esp. Medit. (7 in Brit.). The flrs. of many sp. are adapted to pollination by butterflies, e.g. those of *S. acaulis* L. (moss-campion, a tufted alpine plant); others are pollinated by moths, e.g. *S. inflata* Sm. (bladder campion), which emits its scent at night (p. 92).

Siler Crantz. Umbelliferae (6). 2 sp. Eur., Siberia.

Silphium Linn. Compositae (V). 12 sp. eastern U.S. *S. laciniatum* L. is the famous 'compass-plant' of the prairies. If growing in an exposed position its leaves turn their edges to north and south. They thus avoid the excessive mid-day radiation, and get the full benefit of the morning and evening sun. (Cf. Lactuca.)

Silybum Vaill. ex Adans. Compositae (XI). 2 sp. Medit. *S. Maria-*

num Gaertn. (milk-thistle) in Brit. It is now widely distributed over the Pampas, where it was introduced.

Simaruba Aubl. Simarubaceae. 6 sp. trop. Am.

Simarubaceae. Dicotyledons (Archichl. Geraniales). 28 gen. with 124 sp. trop. and subtrop. Shrubs and trees with alt. pinnate or simple leaves, never gland-dotted. Flrs. small, regular, ☿, often ∞, in axillary compound panicles or cymose spikes. Flr. with K and C 3—7-merous. K free or more often united; C imbricate or rarely valvate; disc between sta. and ovary ring- or cup-like, sometimes enlarged into a gynophore; sta. twice as many as petals, obdiplostemonous, often with scales at the base; cpls. (4—5) or less, often free below and united by the style or stigma; ovules usually 1 in each loc. as in Rutaceae. Schizocarp or capsule; endosperm thin or none; embryo with thick cotyledons. A few yield useful timber. *Chief genera:* Simaruba, Ailanthus. Placed in Geraniales by Benth.-Hooker, in Terebinthinae by Warming.

Simarubeae (Benth.-Hooker) = Simarubaceae.

Simethis Kunth. Liliaceae (III). 1 sp. Brit., W. and S. Eur., *S. bicolor* Kunth.

Sinapis Linn. = Brassica Tourn.

Sinningia Nees. Gesneriaceae (II). 20 sp. Brazil. *S. speciosa* Hiern and others are favourite hot-house plants (generally known as Gloxinias). They are tuberous plants. The usual method of propagation is by planting leaves on the soil; from the base of the petiole a new plant arises by budding (cf. Begonia and Streptocarpus).

Siphocampylus Pohl. Campanulaceae (III). 100 sp. trop. Am.

Siphonia Rich. = Hevea Aubl.

Sison Linn. Umbelliferae (5). 1 sp. Eur., incl. Brit.

Sisymbrium (Tourn.) Linn. (incl. *Alliaria* Adans.). Cruciferae (II. 8). 50 sp. N. temp.; 3 in Brit., incl. *S. officinale* Scop. (hedge-mustard).

Sisyrinchium Linn. Iridaceae (II). 50 sp. Am.

Sium (Tourn.) Linn. Umbelliferae (5). 6 sp. N. Hemisph., S. Afr. 2 in Brit. (water-parsnip). *S. Sisarum* L. (skirret) is sometimes cultivated for its tuberous roots, which are boiled and eaten.

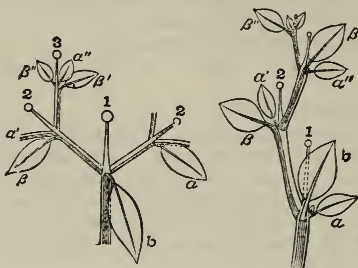
Skimmia Thunb. Rutaceae (IX). 4 sp. Himal., Japan. *S. japonica* Thunb. is often cultivated for its handsome foliage and red berries.

Sloanea Linn.. Elaeocarpaceae. 44 sp. trop.

Smilacina Desf. Liliaceae (VII). 20 sp. N. temp.

Smilax (Tourn.) Linn. Liliaceae (XI). 200 sp. chiefly trop.; also in E. As., N. Am., Medit. Most are climbing shrubs with net-veined leaves. At the base of the leaf spring two tendrils, one on either side, usually regarded as modified stipules, though these organs scarcely occur in Monocotyledons. The stems are often furnished with recurved hooks which aid in climbing. Flrs. diœcious, in umbels. The dried roots of several S. Am. sp. form sarsaparilla.

Smithia Ait. Leguminosae (III. 7). 30 sp. trop. As. Afr.
Smithiantha O. Ktze. = Naegelia Regel.
Smyrnium (Tourn.) Linn. Umbelliferae (5). 1 sp. Medit., Eur., Brit., *S. Olusatrum* L. (Alexanders), formerly used like celery.
Sobralia Ruiz et Pav. Orchidaceae (14). 30 sp. trop. Am.
Soja Moench = Glycine Linn.
Solanaceae. Dicotyledons (Sympet. Tubiflorae). 72 gen. with 1500 sp. trop. and temp.; the chief centre is Cent. and S. Am., where there are 36 local genera; in Eur. and As. only sub-order II. is represented. Herbs shrubs or small trees; leaves in the non-flowering part usually alt., but in the infl.-portion alt. or in pairs; the arrangement in pairs is due to the mode of branching and adnation (p. 30), as illustrated in the figure. In Datura the branching is dichasial, and the bracts are adnate to their axillary shoots up to the point at which the



Branching in Solanaceae (after Eichler); *Datura Stramonium* (left) and *Atropa Belladonna* (right) 1, 2, 3, flrs. or infls. of successive orders; *b*, bract of 1, *α β* bracts of 2, and so on.

next branches arise, so that *α* looks like the bracteole of 2, rather than its bract. In Atropa the branching is cincinnal, one of the two branches at a node remaining undeveloped, and the bract is again adnate to its axillary branch. Of the pair of leaves thus found at any node, one is usually smaller than the other. In Solanum and others further complications occur (see Eichler's *Blüthendiag.*).

Flrs. solitary or in cymes, ☿, sometimes zygomorphic. K (5), persistent; C (5), of various forms, rarely 2-lipped, usually folded and convolute; A 5, alt. with petals, epipetalous, or fewer in zygomorphic flrs.; $\underline{G}$ (2), obliquely placed in the flr. (the posterior cpl. to the right, the anterior to the left, when shown in a floral diagram), 2-loc., sometimes with secondary divisions (e.g. Datura), upon a hypogynous disc; ovules 1—∞ in each loc., anatropous or slightly amphitropous, on axile placentae (most often the placentae are swollen and the ovules numerous); style simple, with 2-lobed stigma. Berry or capsule. Embryo curved or straight, in endosperm. The flrs. are conspicuous and insect-visited; some, e.g. Nicotiana, are adapted to Lepidoptera. A few are economically important, e.g. Solanum (potato), Nicotiana (tobacco), Lycopersicum, Capsicum, &c.; Datura, Atropa, &c. are medicinal; several are favourites in horticulture.

Classification and chief genera (after von Wettstein): the S. are nearly related to Scrophulariaceae, the most general distinction being the oblique ovary; this however is by no means easily made out, and the zygomorphism of the flr. is most often used as a distinction. Certain genera of S. are nearly related to various Boraginaceae, Gesneriaceae, Nolanaceae, &c., and it is quite possible that the S. are not really a simple family (see *Nat. Pfl.*); they occupy a middle place between the Tubuliflorae with actinomorphic, and those with zygomorphic flrs.

A. Embryo clearly curved, through more than a semicircle. All 5 sta. fertile, equal or only slightly different in length.

I. *NICANDREAE* (ovary 3—5-loc., the walls of the loc. dividing the placentae irregularly): Nicandra (only genus).

II. *SOLANEAE* (ovary 2-loc.): Lycium, Atropa, Hyoscyamus, Physalis, Capsicum, Solanum, Lycopersicum, Mandragora.

III. *DATUREAE* (ovary 4-loc., the walls dividing the placentae equally): Datura, Solandra (only genera).

B. Embryo straight or slightly curved (less than a semicircle).

IV. *CESTREAE* (all 5 sta. fertile); Cestrum, Nicotiana, Petunia.

V. *SALPIGLOSSIDEAE* (2 or 4 sta. fertile, of different lengths): Salpiglossis, Schizanthus.

[Placed in Polemoniales by Benth.-Hooker, who unite Nolanaceae to S.; in Personatae by Warming.]

Solanum (Tourn.) Linn. (excl. *Lycopersicum* Hill). Solanaceae (II). 900 sp. trop. and temp. *S. Dulcamara* L. (bittersweet, nightshade) and *S. nigrum* L. in Brit. The flrs. are small, with a cone of anthers opening at the tip as in Borago. *S. tuberosum* L. (S. Am.) is the potato. From the axils of the lowest leaves there spring branches which grow horizontally underground and swell up at the ends into tubers (potatoes). That these are stem structures and not roots is shown by their origin and by their possession of buds—the 'eyes.' Each eye is a small bud in the axil of an aborted leaf (represented by a semicircular rim). When the parent plant dies down in autumn the tubers become detached, and in the next season they form new plants by the development of the eyes, at the expense of the starch and other reserves stored in the tuber (see p. 152). By heaping earth against the stem, so as to cover more of the leaf-axils, more of the axillary shoots are made to become tuber-bearing; hence the value of ridging potatoes. *S. Melongena* L., the egg-fruit, is cultivated in the tropics for its edible fruit. [For *S. Lycopersicum* L. (tomato) see Lycopersicum.]

Soldanella Linn. Primulaceae (I). 4 sp. Alps of Eur. (p. 149). The flrs. expand at very low temperatures, often coming up through the snow; they have a mechanism like that of Erica.

Solenanthus Ledeb. Boraginaceae (IV. 1). 15 sp. Medit., As.

Solidago (Vaill.) Linn. Compositae (III). 80 sp. Am.; 1 in Eur. (incl. Brit.), *S. Virgaurea* L., the golden rod.

Sollya Lindl. Pittosporaceae. 2 sp. W. Austr. Twiners.

Sonchus (Tourn.) Linn. Compositae (XIII). 45 sp. Old World; 3 in Brit. (sow-thistle). Like Hieracium.

Sonerila Roxb. (*Cassebeeria* Dennst.) Melastomaceae (I). 60 sp. Indo-mal., China.

Sonneratia Linn. f. (*Blatti* Adans.). Blattiaceae. 6 sp. Indo-mal. Mangroves (p. 191), with the general habit of Rhizophoraceae. Aerial roots spring vertically out of the mud, arising as lateral, negatively geotropic branches upon the ordinary roots; they are provided with aerenchyma (p. 191), and appear to be respiratory organs (see Goebel, *Ber. D. Bot. Ges.* IV, 1886, p. 249 and *Pflanzenbiol. Sch.* I, p. 139).

Sophora Linn. Leguminosae (III. 1). 25 sp. trop. and warm temp. Winter-buds naked. The wood is very hard.

Sophronitis Lindl. Orchidaceae (13). 4 sp. Brazil, epiphytic.

Sorbus (Tourn.) Linn. = Pyrus Tourn.

Sorghum Linn. (incl. in Andropogon in *Nat. Pfl.*). Gramineae (II). 13 sp. trop. and subtrop. The chief is *S. vulgare* Pers., the millet or guinea corn, largely cultivated in the Medit. region &c. as a cereal. From the halm of the var. *saccharatum* Koern. sugar is sometimes prepared.

Spadiciflorae (Warming). The 3rd cohort of Monocotyledons (p. 137).

Sparganiaceae. Monocotyledons (Pandanales). Only genus Sparganium (q.v.). United to Typhaceae by Benth.-Hooker and Warming.

Sparganium (Tourn.) Linn. Sparganiaceae. 9 sp. N. temp., Austr., N.Z.; 3 in Brit. (bur-weed), in shallow ponds. There is a creeping rhizome and a stem projecting above water with the leaves and flrs. These are in spherical heads, the ♂ heads usually higher up the axis than the ♀. Each flr. has P 3—6, scaly, sepaloid; the ♂ has 3—6 sta., alt. with P. when equal in number; the ♀ has 1 or (2) cpls.; ovule 1, pendulous near base of ovary, with micropyle upwards. Fruit drupaceous, with albuminous seed. Flr. protogynous, anemophilous.

Sparmannia Linn. f. Tiliaceae. 3 sp. trop. and S. Afr. *S. africana* Linn. f. is often grown in hot-houses. Flrs. in cymose umbels (as is easily recognised by their centrifugal order of opening). The sta. are sensitive to contact, moving outwards when touched (cf. Helianthemum).

Spartina Schreb. Gramineae (XI). 7 sp. temp. in salt soil; 1 Brit. (*S. stricta* Roth, cord-grass).

Spartium Linn. Leguminosae (III. 3). 1 sp. Medit., *S. junceum* L., the Spanish broom, resembling the common broom in habit. Flrs. explosive like those of Genista. They yield a yellow dye, and the plant is also used as a source of fibre.

Spathicarpa Hook. Araceae (VII). 4 sp. Brazil and Paraguay. The spadix is adnate to the spathe, and monœcious. Down the centre run 1—3 rows of ♂ flrs., consisting each of a stalked synandrium, rather like a sporophyll of Equisetum; at the sides are the ♀ flrs., consisting each of a bottle-shaped ovary, surrounded by staminodes.

Spathiflorae. The 6th cohort of Monocotyledons (p. 126).

Spathiphyllum Schott. Araceae (II). 20 sp. trop. Am., 1 Phil. Is., Celebes. Spathe partly adnate to spadix. Flr. ☿, with perianth.

Spathodea Beauv. Bignoniaceae (II). 3 sp. trop. Afr. There are large water-pores on the backs of the leaflets near the midrib. In *S. campanulata* Beauv. the flr.-buds have an interesting protection-mechanism, the calyx being inflated and water secreted between it and the corolla (see Treub in *Ann. Buitenz.* VIII).

Specularia Heist. Campanulaceae (I. 1). 10 sp. Medit., Eur., N. Amer. *S. hybrida* A. DC. (*Campanula hybrida* L.) is a cornfield weed in England, and *S. Speculum* A. DC., Venus' looking-glass, is common in gardens. In general the flr. is like that of Campanula.

Spergula Linn. Caryophyllaceae (II. 2). 3 sp. temp. *S. arvensis* L., the spurry, occurs in most parts of the world on arable land. The axillary shoots do not lengthen their internodes, so that the leaves at first glance seem to be tufted. Flrs. in cymes, gynomonœcious or gynodiœcious, homogamous, visited by insects, but self-fertilising in their absence. This plant is sometimes used as fodder.

Spergularia J. et C. Presl (*Buda* Adans., *Lepigonum* Wahlb., *Tissa* Adans.). Caryophyllaceae (II. 2). 20 sp. cosmop., mostly halophytes with fleshy leaves (p. 169). 1 in Brit.

Spermacoce Dill. ex Linn. (*Borreria* G. F. W. Mey.). Rubiaceae (II. 20). 80 sp. trop., esp. Am.

Spermaphyta or Phanerogamae. One of the 4 great divisions of the Vegetable Kingdom, comprising all those plants which produce seeds. The megaspore (embryo-sac) does not fall out of the sporangium (ovule), and the latter ripens, after fertilisation of the ovum, into a seed. In Cryptogamae the spore falls out of its sporangium and germinates upon the soil, so that a seed is not formed. The S. are divided into Gymnospermae and Angiospermae (q.v. and see Ch. II.).

Sphaeralcea A. St. Hil. Malvaceae (II). 21 sp. Cape Col., 4 Am.

Sphaerolobium Sm. Leguminosae (III. 2). 12 sp. Austr.

Sphenotoma Sweet = Dracophyllum Labill.

Spigelia Linn. Loganiaceae. 30 sp. Am. Some sp., e.g. *S. Anthelmia*

L. and *S. marilandica* L. (Indian pink, or pink-root), have apparent whorls of 4 leaves close under the infl.; in reality the internode between the two pairs is very short. Infl. a cyme like that of Boraginaceae. The fruit is a capsule rather like that of Veronica and falls away leaving a sort of cupule. The style is jointed.

Spilanthes Jacq. Compositae (V). 30 sp. Am.

Spinacia (Tourn.) Linn. Chenopodiaceae (4). 2 sp. Orient. *S. oleracea* L. is the common spinach. Annual herbs with cymes of dioecious flrs., anemophilous. The bracteoles harden and surround the fruit as a membranous wing.

Spinifex Linn. Gramineae (V). 4 sp. Austr., Ceylon to Japan. Dioecious. The ♀ spikelets are 1-flowered with long spiny bracts, and are massed together into a head. This breaks off when the fruits are ripe, and blows about (cf. Anastatica), finally sticking in the sand and breaking up (Goebel, *Pflanzenbiol. Sch.* I. p. 135).

Spiraea Linn. (excl. *Ulmaria* Tourn.). Rosaceae (I. 1). 40 sp. N. temp.; *S. Ulmaria* L. = *Ulmaria palustris*.

Spiranthes Rich. (incl. *Sarcoglottis* Presl, *Stenorhynchus* Rich.). Orchidaceae (4). 60 sp. N. temp. and trop.; 3 in Brit., incl. *S. autumnalis* Rich. (lady's tresses). *S. Romanzoffiana* Cham. et Schlecht., a native of N. Am. and Kamtschatka, occurs in meadows at Bantry Bay, Ireland, and has caused much discussion among geographical botanists. The infl. is twisted, so that the flrs. form a spiral. For mechanism of flr. see Darwin, *Orchids*, p. 106.

Spondias Linn. Anacardiaceae (II). 6 sp. trop. The 1—5-seeded drupe is edible (hog-plum).

Sporobolus R. Br. Gramineae (VIII). 80 sp. N. Am., Afr., As., S. Eur.

Spraguea Torr. Portulacaceae. 2 sp. West U.S.

Sprekelia Heist. Amaryllidaceae (I). 1 sp. Mexico, *S. formosissima* Herb., a greenhouse favourite.

Sprengelia Sm. Epacridaceae. 23 sp. Austr., Tasmania.

Stachys (Tourn.) Linn. Labiatae (VI. 4). 200 sp. cosmop., exc. Austr., N. Z.; 5 in Brit., incl. *S. Betonica* Benth. (wound-wort), *S. palustris* L. (marsh betony), &c. The tubers of *S. Sieboldi* Miq. are largely consumed in France &c. under the name of 'crosnes.'

Stachytarpheta Vahl. Verbenaceae (II). 45 sp. trop. and subtrop. (all but one Am.). The leaves of *S. dichotoma* Vahl (*S. jamaicensis* Gardn.) are sometimes used as tea.

Stachyuraceae. Dicotyledons (Archichl. Parietales). Only genus Stachyurus. See *Nat. Pfl.*

Stachyurus Sieb. et Zucc. Stachyuraceae. 2 sp. Japan, Himal.

Stackhousia Sm. Stackhousiaceae. 13 sp. Austr., N. Z.

Stackhousiaceae. Dicotyledons (Archichl. Sapindales). 2 gen. with 15 sp., Austr., N. Z. Herbs, more or less xerophytic with racemose or cymose infls. of ☿ flrs. K (5); C 5, perigynous; disc present;

A 5; $\underline{G}$ (2—5), 2—5-loc., with 1 erect anatropous ovule in each loc.; raphe ventral. Schizocarp. Seed with endosperm. *Genera:* Stackhousia, Macgregoria. Closely allied to Celastraceae. Placed in Celastrales by Benth.-Hooker.

Stackhousieae (Benth.-Hooker) = Stackhousiaceae.

Stangeria T. Moore. Cycadaceae. 1 sp. Port Natal, *S. paradoxa* T. Moore. See order.

Stanhopea Frost. Orchidaceae (19). 20 sp. trop. Am. Epiphytes with large pendulous flrs. The labellum is of a very complex shape (compare its near relative, Coryanthes), forming together with the column, a sort of cage. The mechanism of these flrs. is probably rather complex, and they require careful study in their native districts. In *S. tigrina* Batem., the handsomest of all, whose flrs. are 8 inches across, the labellum and column form a cage narrowing towards the mouth, and of a most extraordinary slipperiness, which leads to the supposition that fertilisation is effected by bees sliding down inside it. The base of the labellum is a bucket-like organ, covered with juicy hairs. Between it and the column are wide openings which enable insects to fly into the bucket. When they come out, finding the opening too narrow to spread their wings, they attempt to crawl out, and reaching the slippery surface where they can get no grip, slide down the cage and so out at the mouth. [For details see *Linn. Soc. Journ.* XXX. 1894, p. 286.]

Stapelia Linn. Asclepiadaceae (II. 4). 80 sp. S. Afr.—the carrion-flower. The chief interest of these plants centres in the fleshy stems. Like the Cacti and the fleshy Euphorbias they inhabit arid regions, and exhibit similar swollen stems, the leaves reduced to thorns or scales, standing in 4 ranks corresponding to the usual leaf arrangement in the order. The green tissue occupies the periphery of the stem, and the centre is full of water storage cells (see p. 167, and compare other succulents). The flrs. are large, with a dull red colour and carrion smell, attracting flies to their aid in fertilisation. The corona is double.

Staphylea Linn. Staphyleaceae. 7 sp. N. temp. Often grown in shrubberies. The capsule is large and bladdery.

Staphyleaceae. Dicotyledons (Archichl. Sapindales). 6 gen. with 20 sp., chiefly N. Hemisph. Shrubs or trees with alt. or opp. leaves, usually unequally pinnate, stipulate. Flrs. in panicles, regular, 5-merous, with the axis forming a cupule and intra-staminal disc. K 5; C 5; A 5; $\underline{G}$ (3), 3-loc. with ∞ anatropous ovules, usually ascending, with ventral raphe. Capsule. Embryo straight, in rich endosperm. For details see *Nat. Pfl.* *Chief genera:* Staphylea, Turpinia. United to Sapindaceae by Benth.-Hooker, placed in Aesculinae by Warming.

Statice Tourn. ex Linn. (incl. *Goniolimon* Boiss.). Plumbaginaceae. 130 sp. cosmop., chiefly in steppes and salt marshes (p. 169). *S.*

Limonium L. (sea-lavender) and 2 others, on the coast of Brit. Infl. compound, mixed, the total infl. being a spike, the partial a drepanium. The flrs. of many sp., *e.g. S. Limonium*, are heterostyled like those of Primula.

Stauntonia DC. Lardizabalaceae. 2 sp. China, Japan.

Staurostigma Scheidw. Araceae (VII). 5 sp. Brazil.

Steironema Rafin. Primulaceae (III). 4 sp. N. Am.

Stelis Sw. Orchidaceae (12). 150 sp. trop. Am.

Stellaria Linn. (incl. *Malachium* Fries). Caryophyllaceae (II. 1). 80 sp. cosmop.; 7 in Brit. (chickweed, stitchwort). Of the Brit. sp., *S. media* Cyrill. has small homogamous flrs. that fertilise themselves in absence of insects; it flowers all the year round, and in winter (apparently on account of weak light, cold, &c.) the flrs. are often cleistogamic (p. 98). The number of sta. is most often 3, but varies a good deal (see Burkill, *Linn. Soc. Journ.* XXXI. 1895). The flrs. of *S. graminea* L. are larger and protandrous, but with autogamy, whilst in *S. Holostea* L. the flrs. are still larger and very protandrous with but little self-fertilisation.

In *S. media* there is a double row of hairs on each internode. Water poured on the plant runs down these, and Stahl explains them as adaptations similar to drip-tips (cf. Ficus), for drying the plant after rain; Lindman thinks they convey the water to the leaf-axils, where it is absorbed by the plant.

Stemonaceae. Monocotyledons (Liliiflorae). 3 gen. with 8 sp., E. Ind., Am., Austr., &c. The chief genus is Stemona Lour. See *Nat. Pfl.*, and Lachner-Sandoval in *Bot. Centr.* 50, p. 65, 1892.

Stenophragma Celak. Cruciferae (IV. 15). 1 sp. Spain.

Stenorhynchus Rich. = Spiranthes Rich.

Stenospermation Schott. Araceae (II). 4 sp. trop. Am., sub-andine.

Stenotaphrum Trin. Gramineae (V). 4 sp. Polynes., Am. *S. americanum* Schrank is useful for binding drift-sand (cf. Ammophila).

Stephanotis Thou. Asclepiadaceae (II. 4). 15 sp. Madag., Malaya, Cuba. Largely cultivated for their scented flrs.

Sterculia Linn. Sterculiaceae. 90 sp. trop. Flrs. unisexual, apetalous.

Sterculiaceae. Dicotyledons (Archichl. Malvales). 48 gen. with 660 sp. chiefly trop. Trees, shrubs, or herbs, with alt. stip. leaves; some are lianes. Flrs. in complex cymes, ☿, usually regular, 5-merous. K (5), valvate, with no epicalyx; C often absent or small, convolute; A in 2 whorls, the outer staminodial or 0, the inner often branched, all more or less united into a tube, anthers 2-loc.; $\underline{G}$ usually (5), with 2—∞ anatropous ovules in each, with the micropyle outwards; style simple, lobed. Fruit various, often a schizocarp. Endosperm. Cola and Theobroma (cacao) are economically important. *Chief genera:* Dombeya, Hermannia, Melochia, Buettneria, Theobroma, Helicteres, Sterculia, Cola. Placed in Malvales by Benth.-Hooker, in Columniferae by Warming.

Stereospermum Cham. Bignoniaceae (II). 12 sp. trop. Afr. As.
Sternbergia Waldst. et Kit. Amaryllidaceae (I). 12 sp. Medit.
Stevia Cav. Compositae (II). 100 sp. trop. and subtrop. Am.
Stifftia Mikan (*Augusta* Leandr.). Compositae (XII). 4 sp. Brazil. Shrubs.
Stillingia Linn. Euphorbiaceae (A. II. 7). 15 sp. Am., Polynes. Mascarenes. [For *S. sebifera* Michx. see Sapium.]
Stipa Linn. Gramineae (VIII). 100 sp. trop. and temp., usually xerophytes. *S. pennata* L., the feather grass of the Steppes, and many others have leaves which roll inwards when the air is dry, covering up the stomata and green tissue (which are on the upper side only) and exposing only the woody lower surface to the atmosphere. The awn of the fruit is very long, ending in a long feather. It is hygroscopic, curling up when dry and uncurling when damp. The fruit is thin and sharply pointed, with backward-pointing hairs on the tip. As in Erodium, the awn when damped uncurls, and, if the point of the fruit be on the soil and the feather be entangled with other objects, drives the fruit into the soil. When the air dries the feather is drawn down, not the fruit upwards. *S. tenacissima* L. (N. Afr.) is the esparto grass, from which paper is extensively made.
Stokesia L'Hérit. Compositae (I). 1 sp. South-east U.S.
Stratiotes Linn. Hydrocharitaceae. 1 sp., *S. aloides* L. (water soldier), Eur. (incl. Brit.). It has a short stem bearing roots and a number of aloe-like leaves with toothed edges. In the summer it floats up to the surface and bears the (diœcious) flrs. It then sinks again, and once more comes up in August or later. Whilst down it gives off numerous axillary shoots with big buds at the ends, and when it floats again these grow into young plants, which soon become free and sink to the bottom, where they remain over the winter. [See p. 158.]
Strelitzia (Banks) Ait. Musaceae. 5 sp. Afr. *S. augusta* Thunb. and *S. Reginae* Banks are often grown in hothouses. Flrs. in a cincinnus in the axil of a large spathe. Sepals free; the lateral petals united, irregular, enclosing the 5 sta. Fertilised by birds (*Ber. D. Bot. Ges.* 1894, p. 53).
Streptanthus Nutt. Cruciferae (I. 1). 22 sp. Pacific N. Am.
Streptocarpus Lindl. Gesneriaceae (I). 30 sp. Afr. The life-history is peculiar. In *S. polyanthus* Hook. (see Hielscher, in Cohn's *Beitr. z. Biol. d. Pfl.*, vol. III) the embryo in the exalbuminous seed has 2 cotyledons and a hypocotyl, but no plumule or radicle; the hypocotyl enters the soil, swells up at the end and developes absorbent hairs; presently however roots (adventitious) form above the swelling, which dies off. In the meanwhile one of the cotyledons continues to grow, while the other dies. Thus the young plant presently consists of a large green cotyledon with few adventitious roots. The cotyledon continues to grow, and reaches a considerable size. Finally the infl. arises as a bud from the base of the petiole, and leafy shoots may also

arise. (Compare the artificial propagation of Sinningia.) Other sp. show somewhat similar phenomena.

Streptocaulon Wight et Arn. Asclępiadaceae (I. 1). 7 sp. E. Ind. to Philippine Is.

Streptochaeta Schrad. Gramineae (VI). 1 sp. Brazil. The awns lever out the fruits in a peculiar way (see F. Müller in *Kosmos*, 1885).

Streptopus Michx. Liliaceae (VII). 4 sp. N. temp.

Streptosolen Miers. Solanaceae (V). 1 sp. trop. S. Am.

Strobilanthes Blume (*Goldfussia* Nees). Acanthaceae (IV. A). 180 sp. trop. As., Madag. Some, *e.g. S. anisophyllus* T. Anders., show marked anisophylly (p. 47). The stigma is sensitive to contact (cf. Mimulus); when touched it moves downwards, and becomes pressed against the lower lip of the flr.

Stromanthe Sond. Marantaceae. 5 sp. trop. Am.

Strophanthus DC. Apocynaceae (II. 5). 28 sp. Cape Col. to China. The free parts of the petals are long and threadlike; the two follicles often stand in a straight line when ripe. The seeds of *S. hispidus* DC. (S. Afr.) furnish the drug strophanthin.

Struthiola Linn. Thymelaeaceae. 24 sp. Cape Col. and trop. Afr.

Strychnos Linn. Loganiaceae. 65 sp. trop. Some sp., *e.g. S. Nux-vomica* L., are erect trees, others are climbing shrubs, with curious hook-tendrils. The hook consists of a modified axillary shoot, and it is noteworthy that the leaf in whose axil it arises does not as a rule develope normally like the one opposite to it on the stem, but becomes a scale leaf. If the hook catch upon a support it twines close round it and thickens and lignifies (cf. Clematis and see p. 170). Other sp. have axillary thorns. A few sp. have a 1-loc. ovary with free-central placenta. The fruit is a berry; the flesh is harmless, but the seeds are exceedingly poisonous, owing to the presence of strychnine in the seed-coats. From these seeds the alkaloid is chiefly obtained. *S. toxifera* Schomb. (S. Am.) yields the famous Wourali or curare poison, with which the S. Am. Indians poison their arrows; it is obtained from the bark by scraping and maceration in water.

Sturmia Rchb. = Liparis Rich.

Stylidieae (Benth.-Hooker) = Candolleaceae.

Stylidium Sw. = Candollea Labill.

Stylochiton Lepr. Araceae (VII). 2 sp. Cent. Afr. The monœcious infl. remains below the ground, only the tip protruding; the spathe opens at the top, and by this opening the pollinating agents enter.

Stylophorum Nutt. Papaveraceae (II). 1 sp. Atlantic N. Am.

Stylosanthes Sw. Leguminosae (III. 7). 25 sp. trop. and subtrop.

Styphelia Sm. (incl. *Cyathodes* Labill., excl. *Leucopogon* R. Br.). Epacridaceae. 30 sp. Austr., N. Z., New Caled., Sandwich Is.

Styracaceae. Dicotyledons (Sympet. Ebenales). 6 gen. with 73 sp. There are 3 centres of distribution—Brazil to Peru and Mexico, Virginia to Texas, Japan to Java. A single sp., *Styrax officinalis*, is Mediterranean, and its presence there may perhaps be referred to Tertiary times, from whose strata various fossil S. have been obtained. Shrubs and trees with alt. simple leaves, usually entire and often leathery. Infl. usually racemose, with no bracteoles. Flr. ☿, regular. K (5—4); C (5—4), often nearly polypetalous; A twice as many as petals, in one whorl, united at base or into a tube, with narrow or linear, rarely round anthers; $\underline{G}$ (3—5), 3—5-loc. below, 1-loc. above, with 1 or few pendulous anatropous ovules in each loc.; style simple, stigma capitate or lobed. Fruit drupaceous, with fleshy or dry dehiscent pericarp, and one or few seeds. Embryo straight, in endosperm. *Chief genera:* Halesia, Styrax. For distinction between S. and Symplocaceae, see the latter order. The absence of latex distinguishes S. from Sapotaceae, the ☿ flrs. from Ebenaceae. Placed in Ebenales by Benth.-Hooker, in Diospyrinae by Warming.

Styrax (Tourn.) Linn. Styracaceae. 60 sp. with distribution of order. *S. officinale* L. yields storax, a resin much used in ancient times. *S. Benzoin* Dryand. (Sumatra, &c.) yields the fragrant resin gum-benzoin, obtained by cutting notches in the bark. It is used medicinally and for incense.

Suaeda Forsk. Chenopodiaceae (9). 40 sp. universal, on the sea-coast, and in salt steppes (p. 169). Herbs with fleshy leaves and dense cymes of flrs. *S. maritima* Dum., the sea-blite, is common on the Brit. coast, and *S. fruticosa* Forsk. is also found.

Subularia Ray ex Linn. Cruciferae (II. 5). 1 sp. Abyss. and 1 sp. in Eur. (incl. Brit.), As., N. Am., *S. aquatica* L., the awl-wort. It grows at the margin of lakes, usually submerged, and has long narrow leaves, nearly circular in section (p. 160.) The flrs. may project above the water and open, or may remain submerged, in which case they fertilise themselves in the bud. This plant is one of the few aquatic annuals.

Succisa Neck. = Scabiosa Tourn. *S. pratensis* Moench = *Scabiosa Succisa.*

Succowia Medic. Cruciferae (II. 9). 1 sp. W. Medit., Teneriffe.

Swainsona Salisb. Leguminosae (III. 6). 30 sp. Austr., N. Z., Siberia.

Swartzia Schreb. (*Tounatea* Aubl.). Leguminosae (II. 9). 60 sp. trop. Am., 1 trop. Afr.

Swertia Linn. Gentianaceae (I. 3). 70 sp. Eur., As., Afr., Am. *S. perennis* L. is often cultivated. The corolla-segments bear each 2 nectaries on the upper side, consisting of little pits covered with hairs.

Swietenia Jacq. Meliaceae. 3 sp. trop. Am., incl. *S. Mahogoni* Jacq., the mahogany, a valuable timber tree.

Sympetalae (Engler, Warming). The higher division of Dicotyledons (pp. 130, 137 and cf. 91).

Symphoricarpos Dill. ex Linn. Caprifoliaceae (III). 8 sp. N. Am. *S. racemosus* Michx. is the snowberry of shrubberies. The pendulous flr. is fertilised chiefly by wasps (cf. Scrophularia). The honey, secreted at the base of the style, is protected from rain, and prevented from flowing out, by the hairs on the corolla. The anthers are towards the outer side of the hairy mass. The wasp, being short tongued (see p. 92), thrusts its whole head into the flr. and touches stigma and sta.; pollen adheres to it as it withdraws its head sticky with honey.

Symphyandra A. DC. Campanulaceae (I. 1). 7 sp. E. Medit. Like Campanula. The pendulous capsule opens at the base (cf. Campanula).

Symphytum Tourn. ex Linn. Boraginaceae (IV. 3). 15 sp. Medit., Eur. *S. officinale* L. (comfrey) is common in Brit. and *S. tuberosum* L., with tubers like those of potato, also occurs. The pendulous flr. is bee-visited; the entrance to the honey is narrowed by the corolla-scales, whose margins are prickly. Mechanism of flr. as in Borago. Some sp. of S. are grown as fodder plants, *e.g.* *S. asperrimum* Donn.

Symplocaceae. Dicotyledons (Sympet. Ebenales). Only genus Symplocos (q.v.). The genus is placed in Styracaceae by Benth.-Hooker &c. The chief distinction is the inferior ovary of Symplocos and its complete division into loculi; the shape of the anthers is also different, and the sta. are often more numerous.

Symplocarpus Salisb. Araceae (III). 1 sp., *S. foetidus* Nutt., the skunk-cabbage, Japan, E. As., Atlantic N. Am.

Symplocos Jacq. The only genus of Symplocaceae (q.v.). 150 sp. trop. and subtrop. Shrubs and trees with alt. simple exstip. leathery leaves, and racemed bracteolate ☿ regular flrs. K (5), imbricate; C (5) or (5 + 5), imbricate; A 5 or 5 + 5 or 5 + 5 + 5 or more, epipetalous or free of corolla; anthers round or ovate; G (2—5), inferior or semi-inferior, with 2—4 anatropous pendulous ovules on an axile placenta in each loc. Style simple, stigma capitate or lobed. Fruit drupaceous, one seed in each loc. of the stone. Embryo straight or curved, in endosperm.

Synanthae. The 5th cohort of Monocotyledons (p. 126).

Synechanthus H. Wendl. Palmae (IV. 6). 3 sp. trop. Am.

Synedrella Gaertn. Compositae (V). 2 sp. trop. Am.

Syngonium Schott. Araceae (VI). 10 sp. W. Ind., Brazil. Climbers with cymes of monœcious spadices. Synandrous.

Syringa Linn. Oleaceae (I. 2). 10 sp. Eur., As. *S. vulgaris* L. is the common lilac, largely cultivated in Brit. (not native). It has well-marked false dichotomy; the terminal bud usually fails to develope each spring and the two nearest lateral buds continue the growth. The winter buds are scaly, and the scales secrete a gummy substance as the bud elongates. The flrs. are in panicles, each branch with a terminal flr. The seeds are flat and slightly winged.

Syringa Tourn. ex Adans. = Philadelphus Riv.

Syzygium Gaertn. = Eugenia Mich.

Tabebuia Gomez. Bigoniaceae (II). 6 sp. trop. Am.

Tabernaemontana Plum. ex Linn. Apocynaceae (I. 3). 110 sp. trop.

Tacca Forst. Taccaceae. 9 sp. trop. As., S. Am. There is a creeping tuberous rhizome bearing large branched leaves on long stalks, and cymose umbels of flrs. on scapes. P 3 + 3, regular; A 3 + 3; $\overline{G}$ (3), 1-loc. with parietal placentae and ∞ anatropous ovules. Style short, with 3 branches petaloid above, each 2-lobed with the stigmas on their under sides. Fruit a berry. East Indian arrowroot is made from the rhizomes of *T. pinnatifida* Forst. and other sp.

Taccaceae. Monocotyledons (Liliiflorae). 2 gen., Tacca (q.v.) and Schizocapsa (fruit a capsule). The order has been placed in many positions in the natural system by various writers (see *Nat. Pfl.*); Benth.-Hooker place it in Epigynae.

Taccarum Brongn. Araceae (VII). 3 sp. Brazil.

Tacsonia Juss. Passifloraceae. 25 sp. trop. Am. United to Passiflora in *Nat. Pfl.*

Tagetes Linn. Compositae (VI). 20 sp. Arizona to Argentina. *T. signata* Bartl. is a favourite border plant.

Talauma Juss. Magnoliaceae (I). 8 sp. trop. E. As. and 4 sp. trop. Am. Like Magnolia, but fruit indehiscent or breaking off from a persistent base.

Talinum Adans. Portulacaceae. 15 sp. Afr., Am.

Talisia Aubl. Sapindaceae (I). 33 sp. S. Am.

Tamaricaceae. Dicotyledons (Archichl. Parietales). 5 gen. with 90 sp. temp. and subtrop. Desert, shore, and steppe plants (p. 169 &c.). Shrubs or herbs with alt. exstip. leaves, often heath-like. Flrs. solitary or in racemose infls., ebracteolate, ☿, regular, hypogynous. K 4—5; C 4—5 (except Fouquieria); A 4—5, 8—10 or ∞, on a disc; $\underline{G}$ (4—5 or 2), 1-loc. Styles usually free. Ovules ∞ or few, on basal-parietal placenta, ascending, anatropous. Capsule. Seeds hairy. Embryo straight; endosperm or not. *Chief genera:* Reaumuria, Tamarix, Myricaria, Fouquieria. Placed in Caryophyllinae by Benth.-Hooker, in Cistiflorae by Warming.

Tamarindus Tourn. ex Linn. Leguminosae (II. 3). 1 sp. trop. Afr., *T. indica* L., the tamarind, largely cultivated in the tropics for its valuable fruit (the part eaten is the pulp round the seeds; it is also officinal). The 2 anterior petals are reduced to bristles, and the 3 fertile sta. united below to form a tube. The wood is useful, not being attacked by insects.

Tamariscineae (Benth.-Hooker) = Tamaricaceae.

Tamarix Linn. Tamaricaceae. 64 sp. Eur., As., Medit. *T. gallica* L. (tamarisk) is a doubtful native on the S. and E. coasts of England. *T. mannifera* Ehrenb. (Egypt to Afghanistan) produces, owing to the punctures of the insect *Coccus manniparus*, the manna of the Bedouins, a white substance which falls from the twigs.

Tambourissa Sonner. Monimiaceae. 14 sp. Java, Mascarenes.

Tamonea Aubl. Melastomaceae (I). 550 sp. trop. Am.

Tamus Linn. Dioscoreaceae. 2 sp. Eur., Medit. *T. communis* L. (black bryony) in Brit. Climbing plants, hibernating by tubers formed by a lateral outgrowth of the first two internodes of the stem.

Tanacetum Tourn. ex Linn. Compositae (VII). 50 sp. N. Hemisph. *T. vulgare* L. (tansy) is often cultivated as a popular remedy in colds &c. Included in Chrysanthemum in *Nat. Pfl.*

Taonabo Aubl. = Ternstroemia Mutis.

Taraxacum Linn. Compositae (XIII). 25 sp. temp. *T. officinale* Weber (dandelion) is almost cosmop. The thick primary root is perennial and is crowned by a very short sympodial stem; each year a new bud is formed on the leafy axis, to come into active growth in the following year. The roots as they grow to maturity contract and thus drag the stem downwards so that it never rises much above the soil. If the root be cut through, a callus forms over the wound, and from this adventitious shoots develope. The floral mechanism &c. are of the usual type of the order, and show the final autogamy very clearly.

Tarchonanthus Linn. Compositae (IV). 3 sp. S. Afr.

Taxaceae. An order of Coniferae (q.v.).

Taxodium Rich. (excl. *Glyptostrobus* Endl.). Coniferae (Arauc. I c; see C. for genus characters). 2 sp. N. Am. (swamp-cypresses), *T. distichum* Rich. and *T. mexicanum* Carr. In the former, and especially in swampy ground, curious 'knees' are formed, which are hollow spherical branches projecting upwards from the roots; they are supposed to be aerating organs (cf. Sonneratia).

Taxus (Tourn.) Linn. Coniferae (Taxaceae, 4; see C. for genus characters). About 8 sp. N. temp., of which *T. baccata* L., the yew, is best known. There are no short shoots, but the leaves of the spreading branches arrange themselves more or less closely in two rows with their upper surfaces nearly in one plane, giving a dorsiventral structure to the shoot. The flrs. are diœcious, solitary in the axils of the leaves of the preceding year. The ♂ has a few scale-leaves below and about 8 or 10 sta., each of which is shield-shaped with a number of pollen-sacs on the axial side of the shield arranged round its stalk like the sporangia in Equisetum. The ♀ has a rather complex structure. The primary axis bears scale-leaves only. In the axil of one of the uppermost of these arises a shoot, continuing the line of the first axis and bearing 3 pairs of scales and a terminal ovule. This is orthotropous with one integument, and developes into a seed surrounded by a cup-shaped red and fleshy aril.

The wood of the yew is valuable; in the middle ages it was the chief material used in making bows. The leaves are very poisonous, but the aril is harmless. Birds swallow it, and thus distribute the seeds.

Tecoma Juss. (incl. *Tecomaria* Spach, *Campsis* Lour., *Campsidium* Seem., *Pandorea* Endl., and other genera retained by Schumann in *Nat. Pfl.*). Bignoniaceae (II). 90 sp. trop. and warm temp. *T. radicans* Juss., which climbs like ivy, is often grown in gardens.

Tectona Linn. f. Verbenaceae (IV). 3 sp. Indo-mal. *T. grandis* L. f. is the teak-tree, largely cultivated in Java, India, &c., for its timber, which is very hard and durable; enormous quantities of it are used for ship-building, &c. The wood sinks in water unless thoroughly dried; this is effected in India by the process of 'girdling,' which consists in removing a ring of bark and sap-wood from the tree near the base. It of course soon dies, and is then left standing for two years.

Teesdalia R. Br. Cruciferae (II. 5). 2 sp. Eur., Medit.; 1 in Brit. The flrs. are arranged in a corymb, which gradually draws out into a raceme as flowering progresses.

Telfairia Hook. Cucurbitaceae (II). 2 sp. trop. Afr., Mascarenes. *T. pedata* Hook. is cultivated for its seeds, which are edible and also yield oil.

Tellima R. Br. Saxifragaceae (I). 7 sp. N.W. Am.

Templetonia R. Br. Leguminosae (III. 3). 7 sp. Austr. Like Bossiaea.

Tephrosia Pers. Leguminosae (III. 6). 120 sp. trop. and subtrop., esp. Afr., Austr.

Terminalia Linn. Combretaceae. 105 sp. trop. The fruits of many sp. are winged (see order). Those of *T. Chebula* Retz. and others (myrobalans) are used in dyeing and tanning, and also in medicine.

Ternstroemia Mutis ex Linn. (*Taonabo* Aubl.). Theaceae. 20 sp. S. Am., 8 As.

Ternstroemiaceae. An order in Bentham and Hooker's 5th cohort (Guttiferales) divided into several orders in Engler's system. The bulk of the genera are placed in *Theaceae*, the rest in *Caryocaraceae*, *Marcgraviaceae*, *Stachyuraceae*, *Dilleniaceae*, &c.

Testudinaria Salisb. Dioscoreaceae. 2 sp. Cape Col. *T. Elephantipes* Salisb. (Hottentot bread) is common in hothouses. It has the general habit of a Dioscorea, but has an enormous tuber projecting out of the soil, with a thick outer coating of cork. This tuber is the swollen first internode of the stem. From it yearly, during the wet season, there springs by adventitious budding the year's shoot, a long thin climbing stem with large leaves and small flrs. This dies down in the dry season, and the corky covering protects the mass of the plant from drought (p. 168).

Tetracera Linn. Dilleniaceae. 45 sp. trop., esp. Am.

Tetragonia Linn. Aizoaceae (II. 3). 50 sp. Cape Col., Austr., N.Z., &c. Sometimes 2 flrs. stand one above the other in the same axil. From the fruit thorny projections grow out which may bear flrs. (a proof of the axial nature of the inferior ovary). *T. expansa* Murr. is often used as a vegetable (New Zealand spinach).

Tetragonolobus Scop. = Lotus Tourn.

Tetramicra Lindl. (*Leptotes* Lindl.). Orchidaceae (13). 1 sp. Brazil.

Tetranthera Jacq. = Litsea Lam.

Tetrapanax C. Koch = Fatsia Dcne.

Tetrapleura Benth. Leguminosae (I. 4). 3 sp. trop. W. Afr.

Tetrapteris Cav. Malpighiaceae. 60 sp. trop. Am., W. Ind. Lianes.

Teucrium (Tourn.) Linn. Labiatae (I. 1). 100 sp. cosmop.; 4 in Brit. (wood sage or germander), incl. *T. scorodonia* L. Flr. with small upper lip, protandrous with movement of style and sta.

Thalia Linn. Marantaceae. 7 sp. trop. and sub-trop. Am. The staminode β (see order) is present.

Thalictrum Tourn. ex Linn. Ranunculaceae (3). 76 sp. N. Temp. (*T. flavum* L., the meadow-rue, and 2 others in Brit.). The flrs. are small; the perianth sepaloid or only slightly coloured and soon dropping off. Some sp. are visited by pollen-seeking insects, but *T. minus* L. and others have become wind-fertilised and protogynous, retaining however traces of their entomophilous ancestry in a slight cohesiveness of the pollen and the fact that as in the rest of the order the anthers dehisce successively (p. 85).

Thapsia Linn. Umbelliferae (9). 4 sp. Medit.

Thea Linn. (excl. *Camellia* Linn.). Theaceae. 8 sp. India to Japan. Often united to Camellia; T. has stalked nodding flrs., C. sessile upright ones. The chief sp. is *T. sinensis* L., the tea plant, largely cultivated in China, India, Ceylon, &c. When growing wild it forms a tree, but in cultivation it is kept pruned into a small bush. The young shoots are nipped off, withered, rolled, fermented (except for green tea), dried, and sorted into grades (pekoe, souchong, congou, &c.). *Cf.* Bald, *Indian Tea*; Watt, *Dict.* [*Synonymy: T. Bohea* L. and *T. viridis* L. = *T. sinensis; T. Camellia* Hoffmgg. = *Camellia japonica.*]

Theaceae. Dicotyledons (Archichl. Parietales). 16 gen. with 175 sp. trop. and subtrop. Trees or shrubs with simple alt. leathery leaves. Flrs. usually solitary, ☿, often partly spiral. K 5, 6 or 7, imbricate, persistent; C 5, rarely 4, 9 or ∞, imbricate; A ∞, rarely 5, 10 or 15, free or in bundles or united into a tube; ovary superior, 2- 3- 5- 10-loc., with 2, 4 or ∞ anatropous ovules in each loc. Capsule or drupe. Embryo usually curved; endosperm little or none. The only important economic plant is Thea; Camellia is a favourite in greenhouses. *Chief genera:* Thea, Camellia, Gordonia, Ternstroemia, Eurya. Benth.-Hooker unite to T. several other genera to form the order Ternstroemiaceae (q.v.). Warming places T. in Cistiflorae.

Thelygonaceae. See Cynocrambaceae.

Thelygonum Linn. (*Cynocrambe* Tourn.). Cynocrambaceae (only genus). 2 sp. Medit., Orient., incl. *T. Cynocrambe* L. (*C. prostrata* Gaertn.). The lower part has opp. leaves, the upper is sympodial with alt. leaves. Opposite each leaf in this part is a group of ♂ flrs. without bracts, while in the axil of the leaf is a branch ending in ♀ flrs. The theoretical explanation (see Eichler's *Blüthendiag.*) is that each limb of the sympodium ends blindly, bearing 2 leaves, only one of which developes. In the axil of the other stands the ♂ infl., while in the axil of the developed leaf arises the 'continuation' shoot of the sympodium, and below this, as an accessory bud, the shoot bearing the ♀ flr. P 2—5, A 10—30; in the ♀ an inferior ovary of 1 cpl. with basal style; ovule campylotropous. Fruit a drupe. The plant is used as spinach, but has an aperient action.

Thelymitra Forst. Orchidaceae (4). 20 sp. Austr. The flr. is almost regular. Some sp. fertilise themselves in the bud, the flr. however afterwards expanding.

Thelypodium Endl. Cruciferae (I. 1). 15 sp. U. S.

Theobroma Linn. Sterculiaceae. 12 sp. trop. Am., of which *T. Cacao* L. is the most important. Its flrs. are borne on the old wood, and give large tough berry-fruits, containing exalbuminous seeds, which after roasting &c., yield cocoa or chocolate. The young leaves are red and pendulous (p. 190).

Theodora Medic. = Schotia Jacq.

Theophrasta Linn. Myrsinaceae (I). 4 sp. W. Ind. The upper part of the stem bears thorny scales. Serial buds occur in the leaf-axils and ultimately cause the phenomenon of stem-flowering (p 190), for flrs. arise in the axils of scale-leaves on these compressed shoots.

Thermopsis R. Br. Leguminosae (III. 2). 15 sp. Himal. to Carolina.

Thesium Linn. Santalaceae. 115 sp. chiefly N. temp. Old World. *T. humifusum* DC. in Brit. (bastard toad-flax). Herbaceous root-parasites with green leaves (see Scrophulariaceae, and p. 176). Flrs. ☿, in racemes. The bract is adnate to the peduncle, and with the 2 bracteoles forms a sort of involucre. P (3—5), tubular. Ovary inferior.

Thespesia Soland. Malvaceae (IV). 4 sp. trop. As., Polynes.

Thevetia Linn. Apocynaceae (I. 3). 8 sp. trop. Am.

Thibaudia Ruiz et Pav. (excl. *Ceratostema* Juss.). Ericaceae (III. 8). 30 sp. trop. Am., often cultivated for their flrs.

Thinouia Planch. et Triana = Thouinia Poit.

Thismia Griff. Burmanniaceae. 6 sp. Indo-mal. Saprophytes. See Groom in *Ann. of Bot.*, June 1895.

Thladiantha Bunge. Cucurbitaceae (I). 8 sp. E. As. to Java. Climbing herbs with root-tubers.

Thlaspi (Tourn.) Linn. Cruciferae (II. 6). 60 sp. Medit., As., N. Am.; 3 in Brit. (penny-cress).

Thouinia Poit. (incl. *Thinouia* Planch. et Triana). Sapindaceae (I). 25 sp. trop. Am., W. Ind. Lianes.

Thrinax Linn. f. Palmae (I. 2). 10 sp. W. Ind. (thatch-palm). The leaves are used for roofing, and the plants also yield useful fibre.

Thrincia Roth = Leontodon Linn.

Thuja Linn. (*Thuya* Linn.). Coniferae (Arauc. 2 b; see C. for genus characters). 4 sp. China, Japan, N. Am., *T. occidentalis* L. is the American, *T. orientalis* L. the Chinese Arbor-vitae. The leaves are small and closely appressed to the stems, which show dorsi-ventral symmetry. Cones of 3 or 4 pairs of scales, the uppermost sterile and often united to form the *columella*, the lowest also often sterile.

[*Synonymy: T. dolabrata* Thunb. = *Thujopsis dolabrata; T. chilensis* Don = *Libocedrus chilensis; T. Doniana* Hook. = *L. Doniana; T. tetragona* Hook. = *L. tetragona; T. gigantea* Carr. = *Libocedrus decurrens.*]

Thujopsis Sieb. et Zucc. Coniferae (Arauc. 2 b; see C. for genus characters). 1 sp. Japan, *T. dolabrata* Sieb. et Zucc.

Thunbergia Retz. (incl. *Meyenia* Nees). Acanthaceae (III). 72 sp. trop. Old World. Many are hothouse favourites. A large number are twiners. The bracteoles enclose the calyx and tube of the flr. and are often united posteriorly.

Thuya Linn. = Thuja Linn.

Thymelaea Tourn. ex Scop. Thymelaeaceae. 20 sp. Medit., W. As.

Thymelaeaceae. Dicotyledons (Archichl. Thymelaeales). 38 gen. with 550 sp., temp. and trop., esp. in Afr. Most are shrubs with entire alt. stip. leaves and racemose infls. Flr. usually ☿, regular 4—5-merous. The receptacle is much hollowed, usually forming a deep tube of leafy consistence ('calyx-tube'); outgrowths of the axis are sometimes found at the base of the tube round the ovary. K petaloid, like the tube, usually imbricate; C conspicuous or small or 0; A as many or twice or half as many as sepals, inserted on the edge of the tube; ovary 1- or rarely 2-loc., each loc. with 1 pendulous anatropous ovule with ventral raphe; style simple. Fruit an achene, berry, or drupe, often enclosed in the persistent receptacle; a few genera have capsules. Embryo straight; endosperm little or none.

Chief genera: Gnidia, Thymelaea, Daphne, Pimelea. The family is a very natural one, but with no very close affinities. Many authors, *e.g.* Benth.-Hooker, place it near Santalaceae, but it is not a typically apetalous family, and seems nearer to Myrtiflorae or Parietales (see *Nat. Pfl.*). Warming places it in Thymelaeinae.

Thymelaeales. The 21st cohort of Archichlamydeae (p. 130).

Thymelaeinae (Warming). The 17th cohort of Choripetalae (p. 137).

Thymus Tourn. ex Linn. Labiatae (VI. 11). 80 sp. Medit., Abyss., Eur. *T. Serpyllum* L. (thyme) in Brit. The flrs. are gynodiœcious (p. 68) with marked protandry. *T. vulgaris* L., the garden thyme, is used in flavouring.

Thyrsacanthus Nees. Acanthaceae (IV. B). 20 sp. trop. Am.

Thyrsopteris Kze. Polypodiaceae. 1 sp. Juan Fernandez.

Thysanocarpus Hook. Cruciferae (IV. 14). 6 sp. Calif.

Thysanotus R. Br. Liliaceae (III). 22 sp. Austr., S.E. As.

Tiarella Linn. Saxifragaceae (I). 4 sp. N. temp.

Tibouchina Aubl. Melastomaceae (I). 190 sp. trop. Am.

Tigridia Juss. Iridaceae (11). 7 sp. Mexico, Cent. Am. *T. Pavonia* Ker-Gawl. (tiger-flower) is common in gardens. The flrs. only last 8—12 hours.

Tilia (Tourn.) Linn. Tiliaceae. 10 sp. N. Temp. *T. platyphyllos* Scop. and other sp. of lime are found, native or planted, in Brit. Note the leaf-mosaic (see order). The flrs. are arranged in little cymes, arising from the axils of the leaves of the current year; the axillary growing point elongates transversely, giving rise to two buds, one of which forms the infl., the other the bud for the next year's growth. The further development of the infl. is too complex for description without figures, but throughout it there occurs 'adnation' of bracts to the axes arising in their axils, a peculiarity particularly noticeable in the first leaf of the infl.-axis, which forms a wing, covering the flrs. from rain and serving to distribute the fruits. [For details see *Nat. Pfl.*] Honey is secreted at the base of the sepals. The flrs. are protandrous and dependent upon insects for their fertilisation; they are largely visited by bees &c., and form a valuable source of honey. The fruit is a nut. The endosperm is very oily, and it has recently been proposed to utilise it commercially. The wood of lime and of *T. americana* L. (bass-wood) is useful. The leaves are usually covered with honey-dew (see Acer).

Tiliaceae. Dicotyledons (Archichl. Malvales). 35 gen. with 380 sp. trop. and temp., chiefly in S.E. As. and Brazil. Trees or shrubs, rarely herbs, with alt. stip. leaves, often showing a well-marked 2-ranked arrangement. In the trees the shoots spread out horizontally and the insertions of the leaves are upon the upper half, so that the divergence is not $\frac{1}{2}$. The end bud of the branch does not develope in the next year. Frequently the leaf is asymmetrical, with the smaller side towards the branch. In the herbaceous forms the leaves are in two ranks diverging at a right angle; torsion of the leaves occurs later on and produces a dorsiventrality. [See pp. 46, 47.] The infl. is always, at least after the first branching, cymose, and often very complex, *e.g.* in Tilia and Triumfetta (q.v.).

Flr. usually ☿, regular, 5—4-merous. K 5 or (5), valvate; C 5, rarely 0, often glandular at base; A usually ∞, free or united in groups, inserted at base of petals or on androphore, with dithecous anthers; $\underline{G}$ (2—∞), 2—∞-loc., with 1—∞ ovules in each loc.; ovules usually ascending, ± anatropous; style simple, with capitate or lobed stigma. Seeds albuminous. The T. yield useful timber, jute (Corchorus) and other fibre. *Chief genera:* Corchorus, Sparmannia, Tilia, Grewia, Triumfetta. Benth.-Hooker unite Elaeocarpaceae to T. and place the order in Malvales; Warming places it in Columniferae. The most constant distinction from Malvaceae is in the dithecous anthers, from Theaceae in the valvate calyx, &c.

Tillaea Mich. ex Linn. Crassulaceae. 26 sp. temp. and trop. (1 Brit.). United to Crassula in *Nat. Pfl.*

Tillandsia Linn. (incl. *Vriesia* Lindl.). Bromeliaceae (4). 160 sp. trop. Am. Some resemble the rest of the order—epiphytes with pitchers—while others, and especially *T. usneoides* L. (long moss, old man's beard, vegetable horsehair), show a different habit. This plant hangs in long grey festoons from the branches of trees, looking rather like a lichen (especially Usnea). At the base, each of the pendent stems is wound round its support, and as the apex grows on downwards the older parts die away, leaving nothing but the axil strand of sclerenchyma (the 'horsehair'). The whole plant is thickly covered with the usual scaly hairs for absorbing the water trickling over it. It has no storage reservoir for water at all. The flrs. when they appear, which is but rarely, are of the usual type. The plant is largely distributed from tree to tree by the wind, small bits breaking off and blowing about. Birds also use it for nesting and thus carry it about. [See p. 173 and Schimper *Die epiph. Vegetat. Amerikas*, p. 67 and Plate II.] It is used like horsehair.

Tinantia Schiedw. Commelinaceae. 3 sp. trop. Am.

Tinospora Miers. Menispermaceae. 14 sp. trop. Old World.

Tissa Adans. = Spergularia J. et C. Presl.

Tithonia Desf. ex Juss. Compositae (v). 10 sp. Cent. Am., W. Ind.

Tithymalus Tourn. ex Hall. = Euphorbia Linn.

Tmesipteris Bernh. Psilotaceae. 1 sp., *T. tannensis* Bernh., Austr., N. Z., Polynes. (rare). It grows as an epiphyte (?parasite) on the trunks of tree ferns. The rhizome bears large lanceolate green leaves.

Tococa Aubl. Melastomaceae (I). 40 sp. trop. S. Am.

Toddalia Juss. Rutaceae (IX). 8 sp. trop. As. Afr.

Todea Willd. Osmundaceae. 4 sp. S. Hemisph. *T. africana* Willd. (*T. barbara* Moore), is apogamous (see Filicineae Leptosporangiatae).

Tofieldia Huds. Liliaceae (I). 15 sp. N. temp. *T. palustris* Huds. (Scottish asphodel) in Brit. Like Narthecium. The flr. has a 3-lobed involucre (*calyculus*) beneath the calyx.

Tolmiea Torr. et Gray. Saxifragaceae (I). 1 sp., *T. Menziesii* Torr. et Gray, N.W. Am. Adventitious buds are formed on the upper part of the petiole. The axial cup is split down the anterior side. Petals thread-like; only the 3 posterior sta. occur.

Toluifera Linn. (*Myroxylon* Forst.). Leguminosae (III. 1). 6 sp. trop. S. Am. *T. Pereirae* Baill. yields Balsam of Peru, and *T. punctata* Baill. Balsam of Tolu, from incisions in the bark; these substances are medicinal.

Tordylium Tourn. ex Linn. Umbelliferae (7). 12 sp. Eur. (1 Brit.), N. Afr., As.

Torenia Linn. Scrophulariaceae (II. 8). 20 sp. trop. As., Afr., Am.

Torilis Adans. = Caucalis Linn.

Tormentilla (Tourn.) Linn. = Potentilla Linn.

Tornelia Gutierrez = Monstera Adans.

Torreya Arn. Coniferae (Taxaceae 4; see C. for genus characters). 4 sp. N. Am., China, Japan. Like Taxus. The timber is useful.
Tounatea Aubl. = Swartzia Schreb.
Tournefortia Linn. Boraginaceae (III). 120 sp. trop. Trees and shrubs.
Tovaria Ruiz et Pav. Tovariaceae. 1 sp. W. Ind., S. Am.
Tovariaceae. Dicotyledons (Archichl. Rhœadales). Only genus Tovaria. United to Capparidaceae by Benth.-Hooker. See *Nat. Pfl.*
Tovomita Aubl. Guttiferae (v). 30 sp. trop. Am.
Townsendia Hook. Compositae (III). 17 sp. Rocky Mts.
Toxicodendrum Thunb. Euphorbiaceae (A I. 1). 1 sp. Cape Colony. The fruit is used for poisoning hyænas.
Toxicophlaea Harv. = Acokanthera G. Don.
Tozzia Linn. Scrophulariaceae (III. 12). 1 sp. Alps, 1 Carpathians (p. 149). Semi-parasites, with loose-pollen flrs. (see order).
Trachelium Tourn. ex Linn. Campanulaceae (I. 1). 7 sp. Medit.
Trachelospermum Lem. Apocynaceae (II. 4). 6 sp. E. As.
Trachylobium Hayne. Leguminosae (II. 3). 3 sp. trop. As., E. Afr. These trees yield copal, which is dug up from the soil near their roots or in a half-fossilised condition from places where trees formerly existed.
Trachymene Rudge. Umbelliferae (I). 14 sp. Austr. to Borneo.
Tradescantia Rupp. ex Linn. Commelinaceae. 30 sp. trop. and N. Am. *T. virginiana* L. (spider-wort) and others are garden favourites. There are 6 perfect sta. covered with hairs. Flr. protandrous.
Tragia Plum. ex Linn. Euphorbiaceae (A. II. 2). 50 sp. trop.
Tragoceros H. B. et K. Compositae (v). 4 sp. Mexico. The corolla of the ♀ flr. becomes rigid after fertilisation has occurred, and forms a double hook upon the fruit.
Tragopogon (Tourn.) Linn. Compositae (13). 35 sp. Old World, N. temp. (*T. pratensis* L., the goat's beard, in Brit.). The flower-heads of the Brit. sp. close up at midday, whence its common name of 'John-go-to-bed-at-noon.' *T. porrifolius* L. is the salsify, sometimes grown as a vegetable.
Trapa Linn. Hydrocaryaceae. 3 sp. Old World (horn-nut), incl. *T. natans* L. and *T. bispinosa* Roxb. Water plants with submerged and floating leaves of different form (p. 160). Flr. ☿, 4-merous, perigynous, with a disc. above the sta. Ovary 2-loc., with one anatropous pendulous ovule in each loc.; raphe ventral. Seed large, exalbuminous, in a horned nut. The seeds are used as food in China, &c. For their remarkable germination see Goebel's or Schenk's works, quoted on p. 158.
Tremandra R. Br. Tremandraceae. 2 sp. Austr.
Tremandraceae. Dicotyledons (Archichl. Geraniales). 2 gen. with 26 sp. Austr. (p. 195). Herbs with whorled, alt. or opp., exstip. leaves.

Flrs. dichlamydeous, regular. K 4—5, rarely (4—5), valvate; C 4—5, valvate; A 8, 10, or rarely 6; G (2), medianly placed; style and stigma simple; ovules 1 or 2 in each loc., anatropous. Capsule, loculicidal or also septicidal. Albuminous seed, with or without aril. *Genera:* Tetratheca, Tremandra. Placed in Polygalinae by Benth.-Hooker, in Aesculinae by Warming.

Tremandreae (Benth.-Hooker) = Tremandraceae.

Trentepohlia Roth = Heliophila Burm. f.

Trianea Karst. = Limnobium Rich.

Tribulus Tourn. ex Linn. Zygophyllaceae. 12 sp. Afr., As., Am., Medit. (caltrops). The mericarps are provided with sharp rigid spines which stick into the foot of any animal treading on the fruit, or may catch in its fur, thus getting distributed. Each mericarp contains 3—5 seeds, and is divided by cross walls which develope after fertilisation.

Trichilia P. Br. Meliaceae. 150 sp. trop.

Trichocline Cass. Compositae (XII). 28 sp. S. Am.

Tricholaena Schrad. Gramineae (V). 10 sp. Afr.. *T. rosea* Nees is cultivated for bouquets.

Tricholepis DC. Compositae (XI). 12 sp. Asia.

Trichomanes Sm. Hymenophyllaceae. 100 sp. with the distribution of the order; *T. radicans* Sw., the bristle fern, in Ireland.

Trichonema Ker-Gawl. = Romulea Maratti.

Trichopilia Lindl. Orchidaceae (28). 18 sp. trop. Am.

Trichosanthes Linn. Cucurbitaceae (III). 42 sp. E. Ind. to Austr.

Trichosma Lindl. Orchidaceae (5). 1 sp. Himal. The axis is lengthened at the top and carries the lateral sepals forward, forming a chin.

Trichosporum D. Don = Aeschynanthus Jack.

Tricyrtis Wall. Liliaceae (I). 5 sp. Himal., E. Asia.

Tridax Linn. Compositae (V). 15 sp. trop. Am.

Trientalis Rupp. ex Linn. Primulaceae (III). 2 sp. N. temp. *T. europaea* L. (chickweed winter-green) sub-alpine in Brit. There is a rhizome with erect stem bearing about 4—7 leaves in a tuft and a few 7-merous flrs.

Trifolium (Tourn.) Linn. Leguminosae (III. 4). 250 sp. temp. and subtrop.; 20 in Brit. (clover, trefoil, shamrock). The flr. has the simplest of the various mechanisms found in the order, the sta. and style emerging as the keel is depressed by an insect resting on the wings, and returning into it when it is released. The flrs. of white clover are an important source of honey; those of red clover are too long-tubed for hive-bees and are visited by humble-bees. *T. subterraneum* L. has two kinds of infl., one normal, the other becoming subterranean. Only 3 or 4 of its flrs. develope, the rest forming grapnels (each sepal forming a reflexed hook); the stalk of the infl. bends downwards and gradually forces the flrs. under the earth, where the fruits ripen (cf. Arachis). *T. badium* Schreb. has a wing upon the fruit formed by the persistent corolla, *T. fragiferum* L. a bladdery 'wing' formed by the calyx. The clovers are important pasture and hay plants; among the chief sp. are *T. repens* L. (white or Dutch clover). *T. pratense* L. (red clover), *T. hybridum* L. (alsike), &c.

Triglochin Riv. ex Linn. Juncaginaceae. 12 sp. cosmop.; 2 in Brit. (arrow-grass), in fresh water- or salt-marshes (*T. palustre* L. and *T. maritimum* L.). Tufted herbs with leafless flowering stems (*scapes*) ending in spikes or racemes. Leaves linear, fleshy in the maritime sp. (p. 187). P 3+3, A 3+3, G (3+3), or sometimes 3 with 3 abortive cpls. between the fertile. By a process of secondary growth the inner whorl of perianth comes to stand higher on the axis than the outer sta. Flr. protogynous, wind-pollinated. The pollen collects in the hollowed bases of the perianth-leaves. The ripened cpls. surround a central beak (cf. Geranium), and are prolonged outwards at the base into long sharp spines, by whose means, breaking away from the beak, they are animal-distributed.

Trigonella Linn. Leguminosae (III. 4). 70 sp. Medit., Eur. (1 Brit.), As., S. Afr., Austr. *T. Foenum-graecum* L. (fenugreek) is sometimes cultivated; its seeds are used in veterinary medicine. The flrs. of *T. Aschersoniana* Urban bury themselves like those of Arachis.

Trigonia Aubl. Trigoniaceae. 26 sp. trop. Am.

Trigoniaceae. Dicotyledons (Archichl. Geraniales). 2 gen. with 28 sp., placed in Vochysiaceae by Benth.-Hooker. See *Nat. Pfl.*

Trillium Linn. Liliaceae (VII). 15 sp. E. As., N. Am. Like Paris.

Trinia Hoffm. Umbelliferae (5). 7 sp. Eur., As., Medit. (1 Brit.).

Triodia R. Br. Gramineae (X). 20 sp. temp. (*T. decumbens* Beauv. in Brit.).

Triopteris Linn. Malpighiaceae. 3 sp. Caribbean Sea.

Triosteum Linn. Caprifoliaceae (II). 5 sp. Himal., E. As., N. Am.

Triphasia Lour. Rutaceae (X). 1 sp. China.

Triplaris Loefl. Polygonaceae (III. 6). 10 sp. trop. S. Am. All are said to harbour ants in their hollow stems (cf. Cecropia). Flr. cyclic (see order), diœcious. The 3 outer perianth-leaves grow into long wings which project beyond the fruit and aid in distribution.

Tripsacum Linn. Gramineae (I). 3 sp. trop. and subtrop. N. Am. *T. dactyloides* L. is a fodder grass. It is like Euchlaena, but with ♂ and ♀ flrs. in the same infl.

Tripteris Less. Compositae (IX). 32 sp. S. Afr. to Arabia. The fruit has three wings.

Trisetum Pers. Gramineae (IX). 50 sp. temp. *T. flavescens* Beauv. in Brit., a good forage grass.

Triteleia Dougl. = Brodiaea Sm.

Triticum Linn. Gramineae (XII). 15 sp. Medit., W. As. The spikelets are 2—5-flowered and arranged in a dense spike. *T. vulgare*

Vill. is the wheat, of which numerous subspecies are cultivated, *e.g.* *T. polonicum* L. (Polish wheat), *T. durum* Desf., *T. Spelta* L. (spelt), *T. dicoccum* Schrank, *T. monococcum* L., &c. (see Körnicke and Werner, *Handb. d. Getreidebaues*, Bonn, 1885, or *Nat. Pfl.*; also Mueller's *Select Extratrop. Plants*). [For *T. repens* L. see Agropyrum.]

Wheat is subject to many diseases; one of the most interesting is rust, which shows as rusty streaks of spores upon the leaves (see Berberis).

Tritonia Ker-Gawl. = Kniphofia Moench.

Triumfetta Plum ex Linn. Tiliaceae. 60 sp. trop. Herbs or shrubs, often with extrafloral nectaries at the base of the leaves. The infl. is peculiar. On each internode there are usually at least three 3-flowered dichasial cymes. The first and oldest is opposite to the leaf; the rest stand alternately right and left between the first and the leaf. [See *Nat. Pfl.*]. The fruit is armed with hooked spines for animal-distribution.

Triuridaceae. Monocotyledons (Helobieae). 2 gen. with about 8 sp. trop. As. and Am. Saprophytes. See *Nat. Pfl.* Placed in Apocarpae by Benth.-Hooker.

Trochodendraceae. Dicotyledons (Archichl. Ranales). 3 gen. E. As. Placed in Magnoliaceae by Benth.-Hooker. See *Nat. Pfl.*

Trollius Linn. Ranunculaceae (2). 12 sp. N. temp. and Arctic. (*T. europaeus* L., the globe-flower, in Brit.) The 'sepals' completely cover in the flr., protecting the pollen from injury. The flr. is homogamous, and regularly fertilises itself, though cross-fertilisation may occur.

Tropaeolaceae. Dicotyledons (Archichl. Geraniales). Only genus Tropaeolum (q.v.). Placed in Geraniaceae by Benth.-Hooker, in Columniferae by Warming.

Tropaeolum Linn. Tropaeolaceae. 35 sp. S. Am., Mexico (Nasturtium or Indian cress of gardens). Most are herbs climbing by sensitive petioles (cf. Clematis), with compound or peltate leaves; some have tubers at the base of the stem. Flr. zygomorphic with a posterior spur formed by the axis under the posterior sepal. K 5, imbricate; C 5; A 4+4; $\underline{G}$ (3), 3-loc. with 1 ovule in each, anatropous, pendulous with micropyle facing upwards and outwards; style simple. Fruit a schizocarp, with no beak. Seed exalbuminous.

Troximon Nutt. Compositae (XIII). 24 sp. W. Am.

Tsuga Carr. Coniferae (Arauc. 1 b; see C. for genus characters). 6 sp. As. N. Am.: evergreen trees with the habit of Picea. *T. canadensis* Carr. is the Hemlock spruce, found in a large part of N. Am. and valued for its wood, bark (used in tanning), pitch (canada pitch), &c. *T.* (*Pseudotsuga*) *Douglasii* Carr. is the Douglas fir, forming large forests in the Rocky Mts. &c.

Tubiflorae. The 5th cohort (Engler) of Sympetalae (p. 131). The 4th cohort (Warming) of Sympetalae (p. 137).

Tulbaghia Linn. Liliaceae (IV). 10 sp. trop. and S. Afr.

Tulipa Linn. Liliaceae (V). 50 sp. N. temp. (tulip), esp. on the steppes of Cent. As. The seeds are flat, and the capsule, even when the flr. is pendulous, stands erect to prevent their escape except when shaken. Many are garden favourites.

Tunica Hall. Caryophyllaceae (I. 2). 20 sp. E. Medit.

Turnera Plum. ex Linn. Turneraceae. 57 sp. trop. and subtrop. Am., 1 Bourbon and Mauritius.

Turneraceae. Dicotyledons (Archichl. Parietales). 6 gen. with 88 sp. chiefly trop. Am. and Afr. Trees, shrubs and herbs, with alt. usually exstip. leaves, whose teeth are sometimes glandular. Flrs. usually solitary in the leaf-axils, ☿, regular, perigynous. K 5, imbricate, usually with a hemispherical swelling on inner side; C 5; A 5; $\underline{G}$ (3), 1-loc. with parietal placentae; styles 3; ovules $3-\infty$, anatropous. Fruit a capsule, loculicidal. Seed with funicular aril, and copious endosperm. Nearly all the T. have dimorphic heterostyled flowers (cf. Primula). Many have extrafloral nectaries. Self-fertilisation occurs, in absence of insect visits, by the corolla withering and pressing the anthers and stigmas together. *Chief genus:* Turnera. Placed in Passiflorales by Benth.-Hooker, in Passiflorinae by Warming.

Turraea Linn. Meliaceae. 40 sp. trop., except Am.

Turritis Tourn. ex Linn. = Arabis Linn.

Tussilago (Tourn.). Linn. Compositae (VIII). 1 sp. Eur., N. Afr., As., *T. Farfara* L., colt's foot, common in Brit. The flrs. appear in spring before the leaves; the plant multiplies and hibernates by aid of underground offshoots. The flower-head is monœcious; in the centre are about 40 ♂ flrs., surrounded by about 300 ♀ flrs. The males retain the style, as usual, to act as pollen-presenter, but it has no stigmas. Honey is secreted in the ♂ flrs., but not in the ♀, so that the head altogether presents a very interesting example of division of labour. The ♀ flrs. being the outer ones are ripe before the ♂, and self-fertilisation is almost impossible.

Tylophora R. Br. Asclepiadaceae (II. 4). 40 sp. Indo-mal., Austr., Afr.

Typha Linn. Typhaceae. 12 sp. temp. and trop., in marshes; 2 in Brit. (reed-mace, cat's-tail, bulrush). The lower part of the stem is a thick rhizome; the upper part projects high out of the water and bears the infl., which is a dense spike, divided into two parts, the upper ♂ (usually yellow), the lower ♀ (brown). ♂ flr. of 2—5 sta., the connective projecting beyond the anthers; the flr. is enclosed in a number of hairs: the ♀ flr. is similarly enclosed, and is of 1 cpl. with 1 pendulous ovule, the micropyle towards the base or ventral side of the ovary. Flr. anemophilous. The fruits are achenes covered by the long downy hairs above mentioned, which aid in distribution. Seed albuminous; embryo straight.

Typhaceae. Monocotyledons (Pandanales). Only genus Typha (q.v.).

Placed (united to Sparganiaceae) in Nudiflorae by Benth.-Hooker, in Spadiciflorae by Warming.

Typhonium Schott. Araceae (VII). 15 sp., E. Ind., Austr.

Ugni Turcz. = Myrtus Tourn.

Ulex Linn. Leguminosae (III. 3). 20 sp. W. Eur., N. Afr.; 3 in Brit., *U. europaeus* L., *U. nanus* Forst., and *U. Gallii* Planch., the gorse, furze, or whin. These plants cover large areas of ground, especially on heaths (p. 185). The leaves are reduced in size, and many of the branches are reduced to green spines, so that the xerophytism is clearly marked. The flrs. explode like those of Genista, and the fruit explodes by the twisting up of its valves in dry air. The seeds in germination show interesting transition-stages from the usual compound leaf seen in the order to the needle-leaf of the mature plant (p. 29, and cf. Acacia).

Ullucus Caldas. Basellaceae. 1 sp. Andes, *U. tuberosus* Caldas. The lateral branches of the rhizome swell up into tubers like potatoes, and are used as food.

Ulmaceae. Dicotyledons (Archichl. Urticales). 13 gen. with 130 sp., trop. and temp. Trees with sympodial stems, bearing 2-ranked simple often asymmetrical leaves with stipules. Flrs. usually in cymose clusters, generally unisexual. P 4—5, free or united, sepaloid, theoretically belonging to two whorls; A 4—5, opp. the perianth-leaves, in two whorls; $\underline{G}$ rudimentary in ♂ flr., in the ♀ of (2) cpls., sometimes 2-loc. but usually 1-loc., the second loc. aborting. Ovules 1 per loc., anatropous or amphitropous, pendulous. Style linear or bifid. Nut, samara or drupe. Seed usually with no endosperm. The wood of many Ulmaceae is useful. *Chief genera:* Ulmus, Celtis. United to Urticaceae by Benth.-Hooker, placed in Urticiflorae by Warming.

Ulmaria (Tourn.) Hill. Rosaceae (III. 8). 8 or 9 herbaceous species of the N. Hemisphere are sometimes separated from Spiraea under this name. They possess 2 seeds in each cpl., 1 only maturing, the fruits being achenes, while most sp. of the genus Spiraea have slightly adherent follicles and are shrubby (cf. Rosaceae). *Holodiscus discolor* Maxim. (*S. ariaefolia* Pursh) links *U.* to Spiraea. *U. palustris* Moench is *S. Ulmaria*, and *U. Filipendula* Hill is *S. Filipendula* of British Floras. The former is the meadow-sweet.

Ulmus (Tourn.) Linn. Ulmaceae. 16 sp. N. temp. and Mts. of trop. Asia. *U. montana* With. (wych elm) and *U. campestris* L. (elm) in Brit. The leaves are asymmetrical, one side being larger than the other (cf. Begonia). The flrs. are ☿ and come out before the leaves as little reddish tufts. If one of these tufts be examined, it will be found to be a short axis with a number of leaves, beginning 2-ranked at the base and going over to 5-ranked above. There are no flrs. in the axils of the lowest 10 or 12; in the axils of the upper leaves are flrs. arranged in small dichasial cymes (cf. Betulaceae), which are reduced, in *U. campestris* and others, to the one central flr. Each flr. has

P 4—8 and as many sta. with a 1-loc. ovary. [See art. Chalazogamae.] The fruit is a samara, adapted to wind-dispersal. The elm supplies a very valuable timber.

Umbellales (Benth.-Hooker). The 15th cohort of Polypetalae (p. 134).

Umbelliferae. Dicotyledons (Archichl. Umbelliflorae). About 180 gen. with 1400 sp., cosmop., but chiefly N. temp. Many in Brit. Most of the order can be recognized at first glance by their habit; they are herbs with stout stems whose internodes are hollow, and alt. exstip. sheathing leaves with their blades much divided in a pinnate manner. A few, *e.g.* Hydrocotyle and Bupleurum, have entire leaves. The infl. is usually a compound umbel. At the top of the stalk, which bears each partial umbel, an involucre of bracts is often found (the bracts of the outer flrs.), and a similar larger involucre often occurs at the top of the main stalk bearing the compound umbel; the latter is sometimes termed the involucre in contradistinction to the *involucels* of the partial umbels. A terminal flr. often occurs, *e.g.* in Daucus. In a number of genera belonging to § A (below) simple umbels occur (*e.g.* Astrantia, Hydrocotyle); these are cymose in type (as the non-centripetal order of opening of the flrs. clearly shows) and are often arranged in cymose groupings, *e.g.* in Sanicula. Eryngium has a cymose head. Some sp. of Xanthosia and Azorella have such cymose infls. reduced to single flrs. These cymose infls., like the racemose, have often involucres of bracts.

Flr. usually ☿ and regular (see below), epigynous. K 5, usually very small, the odd sepal posterior; C 5 (rarely 0), usually white or yellow; A 5, with introrse anthers. On the top of the ovary is an epigynous disc prolonged upwards into the two short styles. $\overline{G}$ (2), antero-posterior, 2-loc.; in each loc. one pendulous ovule, anatropous, with ventral raphe.

The massing of the flrs. into dense infls. makes them very conspicuous (cf. Compositae), and this is aided by the zygomorphism of the corolla so often seen; the outer petals of the outer flrs. of the umbel are drawn out (cf. Cruciferae) so as to form a sort of ray to the umbel. Honey is secreted by the epigynous disc; it is therefore accessible to all kinds of insects, and the order must be placed in the floral class A (p. 89), the lowest of all. [See p. 72.] The chief visitors are flies; bees form only a small proportion of the total. The flrs. are extremely protandrous; in most sp. the male stage is over in all the flrs. of an umbel before even the outer ones have begun the female stage.

The ovary ripens into a very characteristic fruit, a dry schizocarp, which splits down the septum between the cpls. into 2 mericarps, each containing one seed. The two are generally held together at first by a thin stalk (*carpophore*) running up between them. The structure of the pericarp is of great importance in determining the genera. It is nearly always necessary to have ripe fruit in order to identify one of the U. The shape is often important; the outer surface of each mericarp has generally 5 projecting *primary ridges*, two of which (the *lateral ridges*) are at the edges where the splitting takes place. Between these are sometimes found *secondary ridges*, 4 to each mericarp. In the furrows there are often found oil-cavities (seen as small openings in cross-section) known as *vittae*. The seed is often united to the pericarp; it is albuminous with a small embryo in the oily endosperm, which is usually cartilaginous in texture. The shape of the endosperm as seen in cross-section is another character of importance; it may be crescentic, or ventrally grooved, or concave on the ventral side. The fruits often show adaptations for distribution; in many genera (*e.g.* Heracleum and its allies) the mericarp is thin and flat, suited to wind-carriage; in others (*e.g.* Daucus) it is provided with hooks. See also Scandix.

Many U. are economically useful, but as a rule they are poisonous plants. See Daucus (carrot), Pastinaca (parsnip), Apium (celery), Crithmum (samphire), Foeniculum, Archangelica, Carum, Ferula, Pimpinella, Coriandrum, Petroselinum, &c.

Classification and chief genera:

A. *HETEROSCIADIEAE* (simple or irregularly compound umbels; no vittae).

1. *Hydrocotyleae* (fruit compressed laterally, or constricted at the narrow surface of junction): Hydrocotyle, Azorella.
2. *Mulineae* (fruit with narrow surface of junction; mericarps sharp-angled at edge or almost winged): Bowlesia.
3. *Saniculeae* (fruit with broad surface of junction, almost cylindrical or antero-posteriorly compressed): Eryngium, Astrantia, Sanicula.

B. *HAPLOZYGIEAE* (umbels usually compound; furrows of fruit usually with vittae; primary ridges only).

4. *Echinophoreae* (umbel with 1 sessile ♀ flr. in the centre, whose fruit is enclosed by the hardened stalks of the ♂ flrs.; 1 cpl. sterile): Echinophora.
5. *Ammineae* (fruit laterally compressed, or constricted or grooved at both sides of surface of junction): Conium, Bupleurum, Apium, Cicuta, Ammi, Carum, Sium, Pimpinella, Conopodium, Myrrhis, Chaerophyllum, Anthriscus.
6. *Seselineae* (fruit cylindrical or antero-posteriorly compressed, with broad surface of junction, the lateral ridges distinct or united to form a nerve-like corky margin which is not winged): Seseli, Foeniculum, Crithmum, Oenanthe, Aethusa, Meum, Selinum, Levisticum, Angelica, Archangelica.
7. *Peucedaneae* (fruit strongly compressed antero-posteriorly, the lateral ridges broadened into a wing or into a ridge which before separation of the mericarps is undivided): Ferula, Dorema, Peucedanum, Heracleum.

C. *DIPLOZYGIEAE* (umbels compound; fruit with primary and secondary ridges, the latter often the more strongly developed; vittae in the furrows or under the secondary ridges).

8. *Caucalineae* (ribs not winged or with deeply lobed wings or spines): Coriandrum, Cuminum, Daucus, Caucalis.

9. *Laserpitieae* (secondary ridges very marked and often extended into broad undivided or wavy wings): Laserpitium.

"Surface of junction" in the above characters refers to the surface by which the mericarps are united to one another.

[Placed in Umbellales by Benth.-Hooker, in Umbelliflorae by Warming.]

Umbelliflorae. The 23rd cohort (Engler) of Archichlamydeae (p. 130). The 23rd cohort (Warming) of Choripetalae (p. 137).

Umbilicus DC. = Cotyledon Tourn.

Uncaria Schreb. (*Ourouparia* Aubl.). Rubiaceae (I. 6). 30 sp. trop. They climb by hooks, which are metamorphosed infl.-axes, and are sensitive to continued contact; after clasping they enlarge and become woody (p. 172).

Uncinia Pers. Cyperaceae (II). 30 sp. Austr., S. Am. The axis of origin of the flr. projects beyond the utricle in the form of a long hook, serving as a means of dispersal for the fruit.

Uniola Linn. Gramineae (X). 5 sp. Am. Useful as pasture.

Unisexuales (Benth.-Hooker). The 7th series of Incompletae (p. 136).

Unona Linn. f. Anonaceae (3). 40 sp. trop., As., Afr., Austr. Trees or shrubs, the latter climbing by recurved hooks which are infl.-axes (see p. 172). The fruit is an aggregate of stalked berries, which are constricted between the seeds like a lomentum.

Uragoga Linn. (incl. *Cephaelis* Sw. The boundaries of *U.*, *Psychotria* and allied genera are badly-defined. The grouping given by Schumann in *Nat. Pfl.* is followed in this book.) Rubiaceae (II. 15). 150 sp. trop. *U.* (*C.*) *Ipecacuanha* Baill. (*P. Ipecacuanha* Stokes) is the Ipecacuanha plant of Brazil; it is a herb with decumbent stem, and roots thickened somewhat like rows of beads. The root is used in medicine.

Urena Dill. ex Linn. Malvaceae (III). 3 sp. trop. Fruit a schizocarp, the individual cpls. provided with hooks.

Urera Gaudich. Urticaceae (I). 18 sp. trop. The stinging hairs are very powerful. The achene is enclosed in the persistent fleshy perianth, forming a pseudo-berry.

Urginea Steinh. Liliaceae (V). 24 sp. Eur., As., Medit., Afr. *U. Scilla* Steinh. (*U. maritima* Baker) is the squill, with very large bulbs. It is used in medicine.

Uropappus Nutt. = Microseris D. Don.

Urospermum Scop. Compositae (XIII). 2 sp. Medit.

Urostigma Gasp. = Ficus Tourn.

Ursinia Gaertn. Compositae (X). 54 sp. S. Afr., 1 sp. Abyssinia.

Urtica (Tourn.) Linn. Urticaceae (1). 30 sp. temp. (nettles). Herbs with opp. leaves and stipules (sometimes united in pairs between the petioles, as in Rubiaceae). The whole plant is usually covered with stinging hairs. All the various types of infl. are well illustrated by the 3 Brit. sp. In general the infl. is a dichasial cyme with tendency to a cincinnus by preference of the β-bracteole (p. 64). In *U. pilulifera* L. (Roman nettle) the ♂ and ♀ infls. spring side by side from each node, the ♂ catkin-like, the ♀ a pseudo-head. In *U. urens* L. (small nettle) a panicle is formed containing both ♂ and ♀ flrs. In *U. dioica* L. (large or common nettle) there is a panicle, but each sex is confined to its own plant. P 4; A 4, opp. to perianth leaves. The sta. are bent down inwards in the bud, and when ripe spring violently upwards and bend out of the flr., the anther at the same moment turning inside out, so that the loose powdery pollen is ejected as a little cloud, and may be borne by the wind to the stigma. The ♀ flr. has a 1-loc., 1-ovuled ovary with a large brush-like stigma. Achene enclosed in the persistent perianth. The young tops are sometimes eaten like spinach. Useful fibre can be obtained from the stems of the common nettle by maceration.

Urticaceae. Dicotyledons (Archichl. Urticales). 41 gen. with 460 sp. trop. and temp. Most are herbs or undershrubs, with no latex, and with alt. or opp. stip. leaves. Infl. cymose often 'condensed' into pseudo-heads &c. (see Golenkin in *Flora*, 1894). Flrs. usually unisexual and regular. P 4—5, free or united, sepaloid; sta. as many, bent down inwards in bud and exploding when ripe. Ovary 1-loc. with 1 erect basal orthotropous ovule. Fruit an achene. Seed usually with rich oily endosperm; embryo straight. Boehmeria, Urtica, Maoutia and others are used as sources of fibre.

Classification and chief genera (after Engler):

A. With stinging hairs. P (4—5) in ♀. Leaves alt. or opp.

1. *Urereae:* Urtica, Urera, Laportea.

B. No stinging hairs.

2. *Procrideae* (stigma paint-brush-like): Pilea, Pellionia, Elatostema.
3. *Boehmerieae:* Boehmeria, Maoutia.
4. *Parietarieae:* Parietaria.
5. *Forskohleeae:* Forskohlea.

[Benth.-Hooker unite Ulmaceae (distinguished by infl., aestivation of sta., and ovule) and Moraceae (distinguished by presence of latex, and also usually by ovule, embryo, &c.) to Urticaceae, placing the order in Unisexuales. Warming places these 3 orders, separated, in Urticiflorae.]

Urticales. The 5th cohort of Archichlamydeae (p. 127).

Urticiflorae (Warming). The 4th cohort of Choripetalae (p. 137).

Urvillea H. B. et K. Sapindaceae (1). 10 sp. trop. and sub-trop. Am. Lianes like Serjania.

Utricularia Linn. Lentibulariaceae. 200 sp. trop. and temp., the latter all aquatic. 3 in Brit.; the commonest is *U. vulgaris* L., the bladder-wort. The morphology of U. is very interesting, for the usual distinctions drawn between root, stem and leaf cannot be applied here. The common bladder-wort is a submerged water plant with finely-divided leaves; it never has any roots, even in the embryo. The flrs. project above the water on short shoots, and there are also short shoots with small leaves, which arise from the main axis and grow upwards to the water surface. Upon the ordinary submerged leaves are borne the bladders, curious hollow structures with trap-door entrances. Small Crustacea and other animals push their way into the bladders and are not able to escape, for the doors only open from outside. The plant takes up the products of the decay of the organisms thus captured; it is very doubtful whether any special ferment is secreted (p. 177). Other sp. of U. are land plants with peculiar runners, which develope in the moss or other substratum, on which they grow, and there bear the bladders. Others again, *e.g. U. montana* Poir., are epiphytes with water storage in tuberous branches. The leaves of all these forms are simple. Goebel (*Pflanzenbiol. Sch.*) has investigated the development of U. and finds that all these parts—leaves, bladders, runners, water-shoots, erect shoots, &c.—are practically equivalent to one another, and that the same rudiment at the growing point may give rise to any one of them, or that they may themselves change from one to another type. Similarly on germination a lot of spirally-arranged primary leaves are produced, and then one or two water-shoots appear laterally on the growing point, bearing no direct relation to the leaves in position, but apparently homologous with them. "Like Genlisea, U. possessed originally a leaf-rosette, ending with an infl., and consisting partly of bladders. Then were added the swimming water-shoots or (in land forms) runners, which though externally unlike leaves (since they develope indefinitely and produce leaves and infls.) yet are originally homologous with them." For further details see Goebel, *loc. cit.*

Uvaria Linn. Anonaceae (2). 60 sp. Indo-mal. Mostly lianes with recurved hooks (infl.-axes). The connective of the anther is usually leafy.

Vaccaria Medic. = Saponaria Linn.

Vacciniaceae (Benth.-Hooker) = Ericaceae (§ III *Vaccinioideae*).

Vaccinium Linn. (incl. *Oxycoccus* Tourn.). Ericaceae (III. 7). 100 sp. N. Hemisph. There are 4 sp. in Brit. *V. Myrtillus* L. the Whortle-, Bil- or Blae-berry, is extremely common in hilly districts. *V. uliginosum* L. is like it, but is found only at high levels. Both these have deciduous leaves and blue berries. *V. Vitis-Idaea* L., the Cow- or Whimberry (often called Cranberry by error), is also a mountain sp. and evergreen. *V. Oxycoccus* L., the Cranberry, is found in mountain bogs and is a trailing evergreen with leaf edges rolled back (p. 183). The flrs. resemble those of Erica, both in structure and mechanism, except that the ovary is inferior. They are largely visited by bumble-bees. The fleshy fruit is edible (used for jams, &c.) and is much distributed by birds. That of the N. Am. sp. *V. pennsylvanicum* Lam. is called blue huckleberry.

Vahea Lam. = Landolphia Beauv.

Vahlia Thunb. Saxifragaceae (I). 4 sp. Afr., As., trop. and subtrop. The flrs. are in pairs (cymes); ovary inferior.

Vaillantia Tourn. ex Linn. Rubiaceae (II. 21). 2 sp. Medit.

Valeriana Tourn. ex Linn. Valerianaceae. 144 sp. Eur., As., Afr., Am. *V. officinalis* L. and *V. dioica* L. in Brit. (valerian). The flrs. are protandrous. The calyx forms a pappus upon the fruit. The root of *V. edulis* Nutt. (N.W. Am.) is edible when cooked.

Valerianaceae. Dicotyledons (Sympet. Aggregatae). 8 gen. with 215 sp. Eur., As., Afr., Am. Herbs with exstip. leaves and dichasial branching. Flrs. in cymose panicles &c., ☿ or unisexual, asymmetric, usually 5-merous. Calyx superior, little developed at the time of flowering, afterwards often forming a pappus as in Compositae. Corolla (5), often spurred at the base. Sta. 1—4, epipetalous, alt. with petals; anthers introrse. $\overline{G}$ (3); only 1 loc. is fertile, and contains 1 pendulous anatropous ovule. Achene. Seed exalbuminous. *Chief genera:* Valerianella, Valeriana, Centranthus. Placed in Asterales by Benth.-Hooker, in Rubiales by Warming.

Valerianella Tourn. ex Hall. (incl. *Plectritis* DC.) Valerianaceae. 51 sp. N. temp. and S. Am.; 4 in Brit. (corn-salad or lamb's lettuce). The seed-dispersal mechanisms show considerable variety. In *V. Auricula* DC. the sterile loculi of the fruit are inflated, in *V. vesicaria* Moench the calyx is inflated, in *V. discoidea* Loisel. it forms a parachute, whilst in *V. hamata* DC., *V. echinata* DC., and others it is provided with hooks.

Vallisneria Mich. ex Linn. Hydrocharitaceae. 2 sp. trop. and subtrop. *V. spiralis* L. in Eur. is a diœcious submerged water-plant with ribbon leaves (p. 171). The ♂ flrs. are borne in dense spikes enclosed in spathes; when ready to open the flrs. break off and float up to the surface, where they open. The ♀ flr. is solitary on a very long stalk, which brings it to the surface of the water. It has a green perianth, an inferior ovary and 3 large stigmas. Pollination occurs on the surface of the water (cf. Elodea); and after it the stalk curls up into a close spiral, dragging the young fruit to the bottom of the pond to ripen. Vegetative propagation is effected by means of runners, rooting at the ends.

Vancouveria C. Morr. et Dcne. Berberidaceae. 2 sp. N.W. Am. United to Epimedium in *Nat. Pfl.*

Vanda Jones. Orchidaceae (31). 20 sp. Indo-mal. Epiphytes with fleshy leaves, sometimes cylindrical.

Vandellia Linn. (*Lindernia* All.) Scrophulariaceae (II. 8). 26 sp. trop. and subtrop.

Vangueria Juss. Rubiaceae (II. 11). 30 sp. trop. Afr. and As.

Vanilla Plum. ex Linn. Orchidaceae (4). 20 sp. trop. Climbers with fleshy leaves and thin velamen (see order). *V. planifolia* Andr. (Mex.) is cult.; its pods form the spice vanilla.

Vateria Linn. Dipterocarpaceae. 28 sp. Indo-mal., Seychelles. *V. indica* L. yields a gum-resin (Indian copal, white dammar).

Vatica Linn. Dipterocarpaceae. 12 sp. trop. As., Afr. Several yield resins and useful timbers.

Vella Linn. Cruciferae (II. 9). 3 sp. Spain and Algeria. Some are thorny, the thorns being stem structures.

Velleia Sm. Goodeniaceae. 12 sp. Austr. Ovary ± superior.

Vellozia Vand. Velloziaceae. 40 sp. Brazil.

Velloziaceae. Monocotyledons (Liliiflorae). 2 gen. with 70 sp. Brazil, Afr., Madag. Xerophytes, chiefly of rocky places or dry Campos. Perennials with dichotomously branched stems and leaves in rosettes (*cf.* Aloe). The upper parts of the stems are clothed with the fibrous sheaths of old leaves, the lower parts with adventitious roots. The stem itself is thin, but its coating of roots may be several inches deep. Water poured over the roots disappears as if into a sponge, and the plant is thus able to supply itself from the dew, &c. during the dry season. The leaves also are xerophytic (Warming, reviewed in *Bot. Centr.* 56, p. 94). Flrs. solitary, terminal, regular. P $3+3$; A $3+3$, or ∞, in bundles. Ovary inferior, 3-loc., with placenta in the form of lamellae, more or less peltately widened or thickened at the outer side. Ovules ∞. Capsule. Endosperm. *Genera:* Vellozia, Barbacenia. United to Amaryllidaceae by Benth.-Hooker and Warming (chief differences in andrœceum and placentae).

Veltheimia Gleditsch. Liliaceae (V). 3 sp. S. Afr.

Ventilago Gaertn. Rhamnaceae. 10 sp. palaeotrop. Some climb by aid of hooks. Fruit like Fraxinus, having a wing for wind-distribution on its upper end, developed from the style after fertilisation.

Veratrum (Tourn.) Linn. Liliaceae (1). 10 sp. N. temp. Rhizome with leafy stem and racemes of flrs., the lower ☿, but the upper commonly ♂ by abortion (andromonœcism; p. 68). Sometimes plants occur with ♂ flrs. only. Flrs. protandrous. Seeds with a membranous border. Veratrin is obtained from the rhizome; that of *V. album* L. is known as white hellebore root.

Verbascum Tourn. ex Linn. Scrophulariaceae (I. 1). 160 sp. Eur., W. and Cent. As., N. Afr.; 6 Brit. sp. (mullein). Large perennial herbs with stout tap-roots, wrinkled like those of Taraxacum. Infl. primarily racemose, but the lateral flrs. often replaced by condensed dichasia (*cf.* Labiatae). For floral structure and diagram see order. Flrs. chiefly visited for pollen by bees and drone-flies. Those of several sp. were formerly officinal (flores Verbasci).

Verbena Linn. Verbenaceae (II). 80 sp. trop. and temp. *V. officinalis* L., the vervain, occurs in Brit. It was formerly in great repute as a remedy in eye-diseases, its bright-eyed corolla, like that of Euphrasia, being supposed, under the old doctrine of signatures, to indicate its virtues in that direction. Several sp. are cultivated for their handsome and sweetly-scented flrs.

Verbenaceae. Dicotyledons (Sympet. Tubiflorae). About 67 gen. with 750 sp., almost all trop. and subtrop. Herbs, shrubs or trees. A number are lianes (p. 170), *e.g.* sp. of Lantana, Clerodendron, Vitex; xerophytes also, often armed with thorns, are frequent in the order. Leaves usually opp., rarely whorled or alt., entire or divided, exstip. The infl. may be racemose or cymose. In the former case it is most often a spike or head, often with an involucre of coloured bracts. The cymes are usually dichasia with a cincinnus tendency (cf. Caryophyllaceae); sometimes they also form heads.

Flr. usually ☿, zygomorphic, usually 5-merous. K (5) [or (4—8)], hypogynous; C (5), usually with narrow tube, rarely campanulate, often 2-lipped; A 4, didynamous, rarely 5 or 2, or of equal length, alt. with corolla-lobes, with introrse anthers; $\underline{G}$ usually (2), rarely (4) or (5). Ovary superior, usually 4-lobed, originally 2- (or more) loc., but very early divided into 4 (or more) loc. by the formation of a 'false' septum in each loc. (cf. Labiatae); placentae axile, with 2 ovules per cpl. (i.e. 1 in each loc. after septation); ovules ana- to ortho-tropous, basal, lateral or pendulous, but always with the micropyle directed downwards. Style terminal, rarely more or less sunk between the lobes of the ovary (contrast Labiatae); stigma usually lobed. Fruit generally a drupe, more rarely a capsule or a schizocarp. Seed usually exalbuminous.

Several of the V. are useful as sources of timber, *e.g.* Tectona. See also Lippia, Priva, Clerodendron, &c., for other economic uses.

Classification and chief genera (after Briquet):

A. Infl. spicate or racemose. Ovule usually basal, erect, anatropous.

I. *STILBOIDEAE* (endosperm): Stilbe.

II. *VERBENOIDEAE* (no endosperm): Verbena, Lantana, Lippia, Priva, Petraea, Citharexylum.

B. Infl. of cymose type. Cymes often united into panicles, corymbs &c.; if axillary, often reduced to 1 flr.

a. Ovule lateral (sometimes very high up) semi-anatropous. Ovary fully or imperfectly 4—10-loc.

III. *CHLOANTHOIDEAE* (fruit usually drupaceous, never capsular; endosperm): Chloanthes.

IV. *VITICOIDEAE* (as III, but no endosperm): Callicarpa, Tectona, Vitex, Clerodendron.

V. *CARYOPTERIDOIDEAE* (fruit capsule-like, 4-valved: the valves fall taking the stones with them or loosen them from the placental axis): Caryopteris.

b. Ovule apical, pendulous, orthotropous.

VI. *SYMPHOREMOIDEAE* (ovary 2-loc. to centre; fruit dry, 1-seeded): Symphorema.

VII. *AVICENNIOIDEAE* (ovary imperfectly 4-loc.; fruit capsular, 2-valved, 1-seeded; mangroves): Avicennia (only genus).

[Placed in Lamiales by Benth.-Hooker, in Nuculiferae by Warming.]

Verbesina Linn. Compositae (v). 70 sp. Am.

Vernonia Schreb. Compositae (1). 450 sp. Am., Afr., As. The style should be carefully examined, as it is one of the typical styles of the order (see classification of C.).

Veronica (Tourn.) Linn. (excl. *Paederota* L.). Scrophulariaceae (III. 10). 200 sp. extra-trop., many alpine. About 75 in Eur., 17 in Brit. (speedwell). The Brit. sp. are herbaceous (often woody below); the flrs. are in terminal or lateral racemes. The posterior sepal of the 5 typical of this order is absent, and the two posterior petals are united into one large one, so that the perianth is 4-merous (see order for floral diagram). The 2 sta. and style project horizontally from the rotate corolla. A small percentage of flrs. exhibit a different number of parts (*e.g.* 5 petals); see Bateson in *Linn. Soc. Journ.* XXVIII, 1891, p. 386. The fertilisation of the flr. in *V. Chamaedrys* L., the commonest Brit. sp., is performed chiefly by drone-flies. The style projects over the lower petal, while the two sta. project laterally. Honey is secreted at the base of the ovary and concealed by the hairs at the mouth of the short corolla-tube. Insects in alighting on the lower petal touch the style and then grasp the bases of the sta., thus causing the anthers to move inwards and dust the visitors' lower surface with pollen. Other sp. show similar mechanisms, but with more and more tendency to, and arrangements for, self-fertilisation, as the flr. is less conspicuous (Müller, *Fert. of Flrs.*). The peduncles stand close up against the main stem of the raceme whilst the flrs. are in bud, diverge as the flrs. open, and again close up as they wither (p. 104). The fruit is a capsule with a few flattened seeds suited to wind-distribution. In *V. arvensis* L. and other sp. that live in damp places, the capsule merely cracks as it dries and only opens so far as to allow the seeds to escape when thoroughly wetted; the seeds then become slimy (cf. Linum) and can only be distributed to a distance by water (see Macleod in *Bot. Jaarb.* I. p. 91).

Many exotic sp. of V. are shrubby, with handsome spikes of flrs. and are often cultivated. In N. Z. the genus is one of the characteristic alpine plants; 64 sp. occur, of which 59 are endemic (p. 149). Some of these are small trees; most are shrubby (often dwarf). Many of these sp., *e.g. V. cupressoides* Hook. f., are xerophytes with reduced leaves closely appressed to the stem, so that the twigs closely resemble those of Cupressus and other Coniferae; in fact they have been described as Coniferae in systematic works.

Vesicaria Tourn. ex Adans. Cruciferae (IV. 17). 32 sp. Eur., Am.

Viburnum Linn. Caprifoliaceae (II). 100 sp. temp. and subtrop., chiefly As., and N. Am. The winter buds of some sp. are naked, *i.e.* have no scale-leaves. The outer flrs. of the cymose corymb are neuter in some sp., *e.g.* *V. Opulus* L., the guelder-rose, having a large corolla, but at the cost of the essential organs. In the cultivated guelder-rose all the flrs. are neuter.

Vicia Tourn. ex Linn. Leguminosae (III. 9). 120 sp. N. temp., and S. Am.; 10 in Brit. (vetch, tare). Most are climbers with leaf-tendrils. The floral mechanism is typical of many L. The pollen is early shed by the anthers into the apex of the keel; upon the style, below the stigma, is a brush of hairs which carries out the pollen when the keel is depressed (see order). *V. sativa* L. and many other vetches are valuable fodder plants; *V. Faba* L. is the broad bean, with its many varieties.

Victoria Lindl. Nymphaeaceae (III). 2 sp. trop. Am. *V. regia* Lindl. is the giant water-lily of the Amazon. The plant has the habit of a Nymphaea, but is of enormous size. The floating leaves may be 2 m. or more across; the edge is turned up to a height of several cm., and on the lower side the ribs project very far and are armed with formidable spines, perhaps of use as a protection against animals. The flr. resembles that of Nymphaea but is fully epigynous. The fruit also is similar and the seeds contain both endo- and peri-sperm. They are roasted and eaten in Brazil, under the name of Mais del aqua (water-maize). The plant is now cultivated in several gardens, *e.g.* Kew; it was discovered in 1801, but was not brought into general notice till 1837.

Vigna Savi. Leguminosae (III. 10). 40 sp. trop. *V. sinensis* Endl. is the cherry-bean or cow-pea (trop. As.), whose pods are eaten like French beans.

Vilfa Beauv. = Sporobolus R. Br.

Villarsia Vent. Gentianaceae (II). 1 sp. Cape Col. and 9 Austr. The water plant often known under this name is a Limnanthemum.

Vinca Linn. (incl. *Lochnera* Rchb.). Apocynaceae (I. 3). 5 sp. Eur. and Orient (Vinca proper; sta. and stylar head hairy) and 3 sp. E. Ind., Madag., Am. (Lochnera; sta. and stylar head not hairy). Of the latter *V. rosea* L. is a favourite in conservatories. *Vinca minor* L. and *V. major* L., the periwinkles, occur in England, but are not true natives. The anthers stand above the stigmatic disc, but the stigma itself is on the under surface of the disc, so that self-fertilisation is not caused as the insect's tongue enters the flr.

Vincetoxicum Rupp. = Cynanchum Linn.

Viola Tourn. ex Linn. Violaceae. 200 sp. cosmop., chiefly N. temp. Several are common in Brit. *V. odorata* L. and *V. canina* L. are the sweet and dog violets, *V. tricolor* L. the pansy or heart's-ease, and others are also well known. Many sp. and varieties are in cultivation. They are herbaceous plants with large stipules, on which glands sometimes occur. The flrs. stand usually one in each axil; sometimes (*e.g.* *V. tricolor*) a vegetative shoot arises above the flr. in the same axil. The chief interest centres in the flrs. The introrse anthers form a close ring round the ovary, below the style, which ends in a variously shaped head on whose anterior surface is the stigma, often a hollow pocket. The lower petal forms a landing-place and is often prolonged backwards into a spur, in which collects honey, secreted by processes projecting into it from the lower sta. These flrs. are as a rule incapable of self-fertilisation. In *V. tricolor* the pollen is shed on to the anterior petal, and the lower edge of the stigma is guarded by a flap which the insect, when withdrawing, closes; and thus the flower's own pollen is prevented from reaching the stigma. The small-flowered subspecies *V. arvensis* Murr. has not this flap and fertilises itself. In *V. odorata* the stigma is merely the bent-over end of the style, and is first touched as the insect enters. The size, colour, &c., of the flower of this sp. and of *V. canina* render them adapted to bees.

In many sp., *e.g.* *V. canina*, *V. odorata*, *V. sylvestris* Lam., the flrs. are but rarely visited, and very little seed is set. They usually flower early in the season; later on appears a second form of flr. on the same plant. These are the cleistogamic flrs., which never open, but set seed by self-fertilisation (see p. 98). In *V. canina* this flr. looks like a bud; the sepals remain shut, there are 5 very minute petals, 2 anterior sta. with anthers containing a little pollen (only just enough for fertilisation—there is no waste as in open flrs.), and 3 other abortive sta.; the pistil is much as usual. The anthers are closely appressed to the stigma; the pollen-grains germinate within them, and the tubes burrow through the anther-walls into the stigma. *V. odorata* has very similar flrs., but with all 5 sta. fertile. The production of these flrs. ensures the setting of a fair amount of seed. Their appearance is partly dependent on shade (they are always well shaded by the leaves &c.), for a reduction of the intensity of the light causes the plant to produce cleistogamic flrs. only (see Vöchting in *Prings. Jahrb.* 1893). It is however likely that other factors (cold, degree of moisture, soil &c.) also affect the result; and the prduction of these flrs. is apparently hereditary though very variable.

The fruit is a 3-valved capsule; the seeds are very hard and slippery. One placenta with its seeds remains attached to each valve; as this dries it bends upwards into a U-shape, squeezing the seeds against one another and shooting them out (see p. 111, and cf. Claytonia, Buxus).

Violaceae. Dicotyledons (Archichl. Parietales). 15 gen. with 300 sp. cosmop. Annual or perennial herbs, or shrubs. Leaves alt., stipulate, usually undivided. Flrs. 1 or 2 in each axil, in usually racemose infls., bracteolate, ☿, usually zygomorphic. K 5, persistent; C 5, hypogynous, usually zygomorphic, the anterior petal often spurred to hold the honey, with descending aestivation; A 5, alt. with petals, hypogynous, forming a ring round the ovary; filament very short, anther introrse, connective usually with membranous prolongation. G̲ (3), 1-loc. with 1—∞ anatropous ovules on each of the parietal placentae. Style simple. Fruit a 3-valved loculicidal capsule. Endosperm. *Chief genera:* Alsodeia, Viola. Placed in Parietales by Benth.-Hooker, in Cistiflorae by Warming.

Violarieae (Benth.-Hooker) includes Violaceae and the *Sauvagesieae* of Ochnaceae.

Viscaria Riv. ex Rupp. = Lychnis Tourn. *V. viscosa* Aschers. = *L. Viscaria*.

Viscum Tourn. ex Linn. Loranthaceae (2). About 20 sp. universal in the Old World. *V. album* L. in Brit. (mistletoe). It is a semiparasitic shrubby evergreen, growing on apple, hawthorn, oak, &c., and drawing nourishment from its host by suckers. It is repeatedly branched in a dichasial manner, the central stalk usually ending in an infl. Each branch bears two green leathery leaves, and represents a year's growth. The unisexual diœcious flrs. are in groups of three. There is no calyculus. The sta. is completely fused to the perianth-leaf. Pollen-sacs very numerous. Ovary as usual in the order. The flrs. secrete honey and are visited by flies. Fruit a pseudo-berry. The layer of viscin prevents the bird that eats the berry from swallowing the seed, which it scrapes off its bill onto a branch, where it adheres and germinates. [See *Nat. Pfl.* or *Treas. of Bot.*]

Vitaceae (Ampelidaceae). Dicotyledons (Archichl. Rhamnales). 11 gen. with 450 sp. mostly trop. and subtrop. Climbing or rarely erect shrubs, with alt. stip. leaves. Infl. cymose, usually complex; bracteoles present. Flr. regular, ☿ or not. K (4—5), small and cup-like, very slightly lobed; C 4—5, valvate, often united at the tips and falling off as a hood upon the opening of the bud; A 4—5, opp. to the petals, at the base of a hypogynous disc, with introrse anthers. G̲ usually (2), rarely 3—6, multi-loc. with usually 2 collateral anatropous ovules, which are erect with ventral raphe. Berry. Endosperm; embryo straight. Vitis is economically important. *Chief genera:* Vitis, Leea. Placed in Celastrales by Benth.-Hooker, in Frangulinae by Warming.

Vitellaria Gaertn. f. Sapotaceae (I). 15 sp. trop. Am. *V. mammosa* Radlkf. is the marmalade tree, cultivated in the tropics for its fruit.

Vitex Tourn. ex Linn. Verbenaceae (IV). 60 sp. trop. and temp.

Vitis (Tourn.) Linn. (incl. *Ampelopsis* Michx., *Cissus* Linn., *Quinaria* Rafin.). Vitaceae. 350 sp. trop. and warm temp. The vines are climbing plants, with tendrils which represent modified infls.; the stem is usually regarded as a sympodium (p. 42), each axis in turn ending in a tendril, but there has been much argument upon the subject (see *Nat. Pfl.*). The tendril may attach itself by the ordinary coiling method, or may be negatively heliotropic and thus force its way into the crevices of the support; in these crevices the tips of the tendrils form large balls of tissue, the outer parts of which become mucilaginous and cement the tendril to its support. *V. vinifera* L. (Orient, N.W. India) is the cultivated grape; when dried the fruits form raisins. *V. aestivalis* Michx. (summer-grape) and *V. Labrusca* L. (fox-grape) are N. Am. sp. which have been largely introduced into Eur., as they resist the attacks of the Phylloxera better than the Eur. sp. *V.* (*A.*) *hederacea* Ehrh. (N. Am.) and *V. inconstans* Miq. (*A. Veitchii* hort.; Japan) are the virginian creepers so often cultivated.

Vittaria Sm. Polypodiaceae. 10 sp. trop. and subtrop.

Voandzeia Thou. Leguminosae (III. 10). *V. subterranea* Thou. is the only sp. (trop. Afr.); it buries its young fruits like Arachis. The seed is edible and the plant is largely cultivated.

Vochisia Juss. (*Vochysia* Poir.). Vochysiaceae. 54 sp. trop. Am.

Vochysiaceae. Dicotyledons (Archichl. Geraniales). 5 gen. with 100 sp., trop. S. Am. Trees and shrubs. See *Nat. Pfl.* for details. Placed in Polygalinae by Benth.-Hooker.

Vouacapoua Aubl. = Andira Lam.

Voyria Aubl. (incl. *Leiphaimos* Cham. et Schlecht., *Voyriella* Miq.). Gentianaceae (I). 23 sp. trop. Am. and Afr.

Vriesia Lindl. = Tillandsia Linn.

Wachendorfia Burm. Haemodoraceae. 7 sp. Cape Colony. Transverse zygomorphism is found in the flr. but is not obvious on account of the twisting of the stalk.

Wahlenbergia Schrad. (incl. *Hedraeanthus* Griseb.). Campanulaceae (I. 1). 80 sp. chiefly S. temp., where the genus to some extent replaces Campanula. 12 sp. are found in Eur. and As. Minor, one of which, *W. hederacea* Rchb. (*Campanula hederacea* L.), the ivy-leaved bell-flower, occurs in Brit. Flr. like that of Campanula. Capsule loculicidal (the chief difference between these two genera).

Waldsteinia Willd. Rosaceae (III. 6c). 4 sp. N. temp.

Wallichia Roxb. Palmae (IV. 6). 3 sp. Himal. to Malaya.

Washingtonia H. Wendl. Palmae (I. 2). 2 sp. S. Calif., Arizona. Included in Pritchardia in *Nat. Pfl.*

Washingtonia Winsl. = Sequoia Endl.

Watsonia Mill. Iridaceae (III). 11 sp. Afr., Madag.

Wedelia Jacq. Compositae (V). 60 sp. trop. and warm temp.

Weigelia Pers. = Diervilla Tourn.

Weinmannia Linn. Cunoniaceae. 70 sp. S. Am., Madag., N. Z., Austr., Polynes.

Wellingtonia Lindl. = Sequoia Endl.

Welwitschia Hook. f. Gnetaceae. 1 sp., *W. mirabilis* Hook. f., a remarkable plant discovered by Welwitsch in Damaraland (W. trop. Afr.) and described by Hooker in *Trans. Linn. Soc.* 1863 (q.v.). Specimens may be seen in most of our museums. The plant grows for a century or more and has a peculiar habit. The stem is stout, with a two-lobed form and almost circular in section. It narrows downwards into a stout tap-root. At the edges of the two lobes are two grooves, from each of which springs a leaf. These leaves are the first pair after the cotyledons and are the only leaves the plant ever has; they go on growing at the base throughout its life, wearing away at the tips and often becoming torn down to the base. The stem continues to grow in thickness, and exhibits concentric grooves upon the top surface. In the outer (younger) of these grooves the flrs. appear, in panicles of small spikes; they are covered by bracts which become bright red after fertilisation. The flrs. are unisexual. In the ♂, there is a perianth of 2 + 2 leaves, the outer whorl transverse to the bract; sta. 6, united below, with 3-loc. anthers; gynœceum rudimentary, but with the integument of the ovule looking like a style and stigma. In the ♀, the perianth-leaves are fused into a tube, and are equivalent to the two outer leaves of the ♂; there is no trace of sta. Ovule 1, erect, with the integument drawn out beyond it. Seed with endosperm and perisperm, enclosed in the perianth which becomes winged. [See Gymnospermae.]

Werneria H. B. et K. Compositae (VIII). 30 sp. Andes, Himal., Abyssinia.

Westringia Sm. Labiatae (II). 12 sp. Austr.

Whipplea Torr. Saxifragaceae (III). 2 sp. West U. S.

Whitlavia Harv. = Phacelia Juss.

Widdringtonia Endl. = Callitris Vent.

Wigandia H. B. et K. Hydrophyllaceae. 6 sp. Mts. of trop. Am.

Willughbeia Roxb. Apocynaceae (I. 1). 10 sp. Malaya, Ceylon, Assam.

Winterana Linn. = Canella P. Br.

Winteranaceae = Canellaceae.

Wistaria Nutt. (*Bradburya* Rafin. in part, *Kraunhia* Rafin.). Leguminosae (III. 6). 5 sp. China, Japan, N. Am. *W. chinensis* DC. (China) is a climbing shrub often grown on houses in Brit. for its beautiful and sweet-scented flrs. The floral mechanism is like that of Trifolium. The pods explode violently.

Witsenia Thunb. Iridaceae (II). 1 sp. Cape Colony. Several sp., cultivated as W., belong to Aristea and other genera.

Wolffia Horkel. Lemnaceae. 6 sp. trop. and temp. *W. arrhiza* Wimm. in Brit. (the smallest of flowering plants).

Woodfordia Salisb. Lythraceae. 2 sp., one Abyss., and 1 (*W. floribunda* Salisb.) Madag., Ind., China, Timor.

Woodsia Br. Polypodiaceae. 15 sp. alpine and arctic. *W. ilvensis* Br. and *W. hyperborea* Br. are rare alpine ferns in Brit.

Woodwardia Sm. Polypodiaceae. 6 sp. N. Hemisph.

Wormia Rottb. Dilleniaceae. 20 sp. trop. As., Afr. Included in Dillenia in *Nat. Pfl.*

Wrightia R. Br. Apocynaceae (II. 5). 10 sp. trop., Afr., As., Austr.

Wulfenia Jacq. Scrophulariaceae (III. 10). 3 sp. Eur., As.

Wyethia Nutt. Compositae (v). 12 sp. western N. Am.

Xanthium (Tourn.) Linn. Compositae (v). 4 sp. temp. and trop. They have been so widely distributed by man (unintentionally) that it is hard to discover their native place. The flrs. are in unisexual heads, which are single or in axillary cymes, the ♂ at the ends of the branches. The ♀ head has 2 flrs., enclosed in a prickly gamophyllous involucre, only the styles projecting from it through openings in the two horns of the involucre. The fruits are enclosed in the hard woody involucre, which is covered with hooks and is admirably suited to animal-distribution. One sp. has gradually spread in this way from the East of Europe. "In 1828 it was brought into Wallachia by the Cossack horses, whose manes and tails were covered with the burrs. It travelled in Hungarian wool, and in cattle from the same region, to Regensburg, and on to Hamburg, appearing here and there on the way." Strenuous laws for its extirpation have been enforced in South Africa, where at one time it had become so common as seriously to impair the value of the wool.

Xanthochymus Roxb. = Garcinia Linn.

Xanthophyllum Roxb. Polygalaceae. 40 sp. Indo-mal. Ovary 1-loc. with parietal placentae. Nut one-seeded.

Xanthorrhiza Marshall = Zanthorhiza L'Hérit.

Xanthorrhoea Sm. Liliaceae (III). 11 sp. Austr. The best known is *X. hastilis* R. Br., the grass-tree or black-boy, a characteristic plant of the Austr. vegetation (p. 196). It has the habit of an Aloe or Dasylirion, with a long bulrush-like spike of flrs. (really cymose as may be seen from the many bracts on the individual flr.-stalks). Perianth sepaloid (X. is placed in Juncaceae by Benth.-Hooker). From the bases of the old leaves trickles a resin, used in making varnish, sealing-wax, &c.

Xanthosia Rudge. Umbelliferae (I). 17 sp. Austr. The umbels in some sp. are reduced to single flrs.

Xanthosoma Schott. Araceae (VI). 20 sp. trop. Am. Large herbs (fig. in Kerner's *Nat. Hist.*). *X. appendiculatum* Schott has a second blade at the back of the leaf, united with the chief one along the midrib, and much smaller than it. A pocket is thus formed whose use is unknown. The phenomenon is due to a tangential division of the embryonic leaf. Flrs. monœcious, naked; sta. in synandria.

Xanthoxylum J. F. Gmel. = Zanthoxylum Linn.

Xeranthemum Tourn. ex Linn. Compositae (XI). 6 sp. Medit., Orient.

Xiphion Tourn. ex Mill. = Iris Tourn.

Xylomelum Sm. Proteaceae (II). 4 sp. Austr. The fruits are known as wooden pears, being of the size of a large pear, and looking at first glance as if they were edible. Inside is found a thick wall of woody tissue enveloping the winged seeds. It splits open along the posterior side. This sort of fruit is found in several Proteaceae and is looked on as an arrangement for protection of the seeds from the drought (p. 168).

Xylophylla Linn. = Phyllanthus Linn. (the sp. with phylloclades).
Xylopia Linn. Anonaceae (6). 60 sp. trop.
Xylopleurum Spach = Oenothera Linn.
Xylosma Forst. f. = Myroxylon Forst.
Xyridaceae. Monocotyledons (Farinosae). 2 gen. (Xyris, Abolboda) with 50 sp. trop. and subtrop., mostly Am. Mostly marsh plants, herbaceous, tufted, with radical sheathing leaves and spikes or heads of ☿ flrs. Perianth heterochlamydeous. K 3, the lateral sepals small, the anterior large, enclosing the corolla; C (3). Sta. 3, epipetalous, the outer whorl absent or represented by staminodes. Ovary 1-loc. or imperfectly 3-loc., with parietal or free basal placentation and ∞ orthotropous ovules. Embryo small, in mealy endosperm. Placed in Coronarieae by Benth.-Hooker, in Enantioblastae by Warming. [See review in *Bot. Gaz.* 1893, p. 313.]
Xyrideae (Benth.-Hooker) = Xyridaceae.
Xyris Gronov. ex Linn. Xyridaceae. 40 sp. trop. and subtrop.
Yucca Dill. ex Linn. Liliaceae (VI). 20 sp. Southern U.S., Mexico, &c. Many are hardy in this country (Adam's needle). The stem is short, growing in thickness, and branching occasionally (cf. Dracaena); at the end is a rosette of leaves, the old ones dying off below. The leaves are fleshy and pointed. The flrs. are large and white and form a big panicle. Their chief interest is the very remarkable mode of pollination (for details and figures see Riley in *3rd Ann. Rep. Missouri Bot. Gdn.* 1892). This is one of the few cases of mutual dependence and adaptation of a single flr. and a single insect—Pronuba, a moth. The white flr. emits its perfume especially at night, and is then visited by the moths. The female has a long ovipositor with which she can penetrate the tissue of the ovary of the flr., and possesses peculiar maxillary tentacles confined to the genus, which are prehensile and spinous. "Her activity begins soon after dark, but consists, at first, in assiduously collecting a load of pollen. She may be seen running up to the top of one of the stamens....The maxillary palpi are used in this act very much as the ordinary mandibles are used in other insects, removing or scraping the pollen from the anthers towards the tentacles. After thus gathering the pollen she raises her head and commences to shape it into a little mass or pellet...." She repeats the operation on several flrs., until she has a pellet about thrice as large as her head. The moth then flies to *another* flr. and proceeds to deposit a few eggs in the ovary, piercing its wall with her ovipositor. Having done this she climbs to the top and presses the ball of pollen that she has gathered into the stigma. The result is that the ovules are fertilised, but they are so numerous that there are plenty for the larvae to feed upon and also to reproduce the plant.

The leaves of *Y. filamentosa* L. and other sp. furnish an excellent fibre (cf. Agave).

Zahlbrucknera Rchb. Saxifragaceae (1). 1 sp. Europe.
Zalacca Rumph. Palmae (III. 5). 10 sp. Indo-mal.
Zaluzania Pers. Compositae (V). 8 sp. Cent. Am.
Zaluzianskya F. W. Schmidt. Scrophulariaceae (II. 7). 16 sp. S. Afr.
Zamia Linn. Cycadaceae. 30 sp. trop. Am.
Zamioculcas Schott. Araceae (1). 1 sp. trop. Afr., Bourbon. Leaves pinnate.
Zannichellia Mich. ex. Linn. Potamogetonaceae. 1 sp. *Z. palustris* L., cosmop. It grows in fresh or brackish water, and has the habit of a small-leafed Potamogeton. Flrs. monœcious; the ♀ is terminal, and from the axil of its lower bracteole springs the ♂. From the axil of the upper a new branch may arise, bearing ♀ and ♂ flrs. again. The ♂ flr. consists of 1 or 2 sta., the ♀ of usually 4 cpls., surrounded by a small cup-like perianth. Pollination occurs under water as in Zostera, but the pollen is spherical.
Zanonia Linn. Cucurbitaceae (1). 2 sp., *Z. indica* L. (E. Ind. to New Guinea) and *Z. macrocarpa* Blume (Sunda Is.). The latter has enormous flat winged seeds which float very well in the air, and are remarkably like the seeds of many Bignoniaceae.
Zantedeschia Spreng. = Richardia Kunth.
Zanthorhiza L'Hérit. Ranunculaceae (2). 1 sp. Atlantic N. Am. Flrs. 5-merous throughout, and polygamous.
Zanthoxylum Linn. (incl. *Fagara* Linn.). Rutaceae (5). 140 sp. trop. and N. Am., As. Several are cultivated in shrubberies. *Z. piperitum* DC., the Japan pepper, yields fruits used as a condiment. The bark of *Z. fraxineum* Willd. (prickly ash or toothache-tree) is used in Am. as a remedy for toothache. The prickly stems of *Z. Clava-Herculis* L. are used as walking sticks.
Zauschneria Presl. Onagraceae (II). 1 sp. Calif., Mexico.
Zea Linn. Gramineae (1). 1 sp., *Zea Mays* L., the maize or Indian corn, apparently originally a Mexican sp., but now cultivated in most trop. and subtrop. regions. It is a tall annual grass, with terminal ♂ infl. and ♀ infls. in the axils of the foliage-leaves. The ♂ spikelets are borne in pairs, and are 2-flowered. The ♀ infl. forms a 'cob' with long filamentous stigmas hanging out at the end (the flrs. are pollinated by wind). The cob is enveloped when young by large spathe-leaves, and consists of combined spikes; each two rows of flrs. visible on its surface correspond to one spike of flrs. The cultivated forms are 8-, 10-, 12-, or 24-rowed. This should be compared with Euchlaena, in which the spikes are distinct and form a tuft. Each spike consists of one-flowered spikelets. The fruit is the familiar maize-seed, in which the structure of a grass-fruit can easily be made out; the embryo occupies the white portion near the pointed end.

Next to rice, maize is the most important cereal; it is termed corn in the U.S., like wheat in England, oats in Scotland. The grain is made into flour (Indian meal) or cooked without grinding; green corn (unripe cobs) forms a favourite vegetable; the leaves are useful as fodder, the dry cobs as firing; the spathes are used in paper-making, and so on. [See Harshberger's monograph (botanical and economic) in *Contrib. from the Bot. Laboratory of the Univ. of Pennsylvania* I. 1893.]

Zelkova Spach. Ulmaceae (II). 4 sp., 1 each in Crete, Caucasus, China, Japan. The timber of the last two is valuable for turning &c. [Urticaceae, Benth.-Hooker; see Ulmaceae.]

Zephyranthes Herb. Amaryllidaceae (I). 30 sp. trop. Am.

Zeuxine Lindl. Orchidaceae (4). 20 sp. trop. Afr. to E. Ind.

Zingiber Adans. Zingiberaceae. 20 sp. E. Ind., Malay Arch., China, Japan, Polynes., Mascarenes. The labellum is large; opp. to it are the style and the petaloid fertile sta. The stigma has many rays. *Z. officinale* Rosc. is the ginger; it is always reproduced by vegetative methods, and is now quite sterile (cf. Musa). It is largely cultivated; the rhizomes are dug up and killed by immersion in boiling water. According to whether the rind is or is not scraped off, the product is known as 'coated' or 'scraped' ginger.

Zingiberaceae. Monocotyledons (Scitamineae). 24 gen. with 275 sp. trop., chiefly Indo-mal. Perennial herbs usually with sympodial fleshy rhizomes and often with tuberous roots. The aerial stem, if any, is short; sometimes an apparent stem is formed as in Musa by the rolled-up leaf-sheaths. Leaves 2-ranked, with short stalks and sheathing bases. At the top of the sheath is a characteristic ligule (cf. Gramineae). Flrs. in racemes, heads, or cymes. Their morphology has been much discussed (see Eichler's *Blüthendiag.* or *Nat. Pfl.*). The bracteole is often sheathing (as in fig.). K (3), the odd one anterior, C 3, usually different in colour and texture from the outer perianth-leaves. Of the possible 6 members of the andrœceum (two whorls), the posterior one of the inner whorl is present as a fertile stamen, and the other two of this whorl are united to form the petaloid *labellum* (not equivalent to that of Orchids); the anterior sta. of the outer whorl is always absent; the other two may be absent (as in Renealmia) or may be present as large leafy staminodes right and left of the fertile sta. (compare carefully with Cannaceae and Marantaceae). $\overline{G}$ (3), 3-loc., with ∞ anatropous or semi-anatropous ovules. Fruit usually a loculicidal capsule. Seeds with perisperm. The order contains several economic plants; see Curcuma, Costus, Alpinia, Zingiber, Amomum, Elettaria.

Floral diagram of Renealmia, modified from Eichler, showing bract, sheathing bracteole, calyx, corolla, labellum (LAB), &c.

Chief genera: Curcuma, Hedychium, Costus, Alpinia, Renealmia, Zingiber, Amomum, Elettaria, Globba, Mantisia. Placed in Scitamineae by Warming; Benth.-Hooker unite all the orders—Z., Musaceae, Cannaceae, and Marantaceae—into one order under the name of Scitamineae.

Zinnia Linn. Compositae (v). 12 sp. N. Am., favourite border plants. Leaves opp. or whorled. Fruit winged.

Zizania Gronov. ex Linn. Gramineae (vi). 2 sp. Am., N.E. As., *Z. aquatica* L. (*Hydropyrum esculentum* Link), Canada rice, is used as a cereal by the N. Am. Indians.

Ziziphora Linn. Labiatae (vi. 8). 12 sp. Medit., Asia.

Zizyphus Tourn. ex Linn. Rhamnaceae. 40 sp. Indo-mal., trop. Am., Afr., Austr., Medit. The stipules are often represented by thorns, one of which is sometimes recurved whilst the other is straight (cf. Paliurus); occasionally only one is developed. *Z. chloroxylon* Oliv. (cogwood; Jamaica) yields a hard tough wood, used for cogs in machinery. The fruits of many sp. are edible; those of *Z. Lotus* Lam. (Medit.) are said to be the Lotus fruits of antiquity; those of *Z. vulgaris* Lam. (Orient &c.) are known as French jujubes; those of *Z. Joazeiro* Mart. are used in Brazil as fodder for cattle during the dry season. *Z. Spina-Christi* Willd. is said to have furnished the crown of thorns (cf. Paliurus).

Zostera Linn. Potamogetonaceae. 5 sp. temp., subarct., subtrop., growing in salt water on gently sloping shores (p. 187). *Z. marina* L. and *Z. nana* Roth in Brit. (eel-grass or grass-wrack). The lower part of the stem creeps, rooting as it advances along the ground, and has ordinary monopodial branching; the branches grow upwards into the water and exhibit sympodial branching, complicated by union of the axillary shoot to the main shoot for some distance above its point of origin. This is most easily seen in the infl. region; the branching is that of a rhipidium (p. 65), but the shoot II, which springs from the axil of a leaf on shoot I, is adnate to I up to the point at which the first leaf is borne on II; this leaf occupies the angle between the two shoots where they separate. Shoot I (and II, III, &c. successively) is pushed aside and bears an infl. (See Eichler's *Blüthendiag.* or *Nat. Pfl.* for details and figs.) The leaves are long, linear, and sheathing at the base.

The infl. is a flattened spadix, enclosed at flowering time in a spathe (the sheath of the uppermost leaf). This is open down one side, and on the corresponding side of the spadix the flrs. are borne, the essential organs forming two vertical rows, each composed of a cpl. and a sta. alternately. On the outer side of the spadix next the cpl. is often a small leaf (the *retinaculum* of systematic works). The midrib of the cpl. faces outwards. Each cpl. contains one ovule and has two flat stigmas. The sta. consists of two half anthers, joined by a small connective. It is difficult to decide what is the actual 'flower' in this plant; the usual view is that

ret.	cpl.	sta.	
	sta.	cpl.	ret.
ret.	cpl.	sta.	

each sta. with the cpl. on the same level with it forms a flr., the retinaculum representing the bract.

Fertilisation occurs in a peculiar way, Z. being one of the water plants most completely modified from the ancestral land-plant type (see p. 158). The flr. is submerged like the rest of the plant. The pollen grains are long threads, of the *same* specific gravity as salt water, so that when they are discharged they float freely at any depth. The stigmas are very large, and thus have a good chance of catching some of the grains. The whole mechanism is very similar in principle to that of a wind-fertilised plant. The fruit is an achene. Delpino looks upon Z. as an Aroid, adapted to a submerged existence. In winter it hibernates without any special modification. The plant is largely used for packing glass, stuffing cushions, &c., especially in Venice. [For further details see order, also p. 158 and Schenk's *Wässergewächse.*]

Zygadenus Michx. Liliaceae (1). 10 sp. N. Am., Siberia.

Zygopetalum Hook. (incl. *Pescatorea* Rchb. f.). Orchidaceae (20). 20 sp. trop. Am., epiphytic. The base of the column forms a chin.

Zygophyllaceae. Dicotyledons (Archichl. Geraniales). 22 gen. with 140 sp. xero- or halo-phytes, trop. and subtrop. Most are woody perennials; leaves opp., stip., usually hairy, fleshy or leathery. Flrs. in cymes, regular, ☿. K 5; C 5; A 5 + 5; obdiplostemonous and with ligular appendages; $\underline{G}$ (5). Ovary 5-loc. with 1 or more pendulous ovules in each loc. Fruit usually a capsule. Seeds with or without endosperm. Guaiacum, Peganum, &c. furnish useful products. *Chief genera:* Zygophyllum, Guaiacum, Porlieria, Larrea, Peganum, Tribulus. Placed in Geraniales by Benth.-Hooker, in Terebinthinae by Warming. Closely related to Rutaceae.

Zygophyllum Linn. Zygophyllaceae. 60 sp. Old World, deserts and steppes. Leaves and twigs fleshy.

SUPPLEMENT TO PARTS I. AND II.

CORRECTIONS AND ADDITIONS.

INTRODUCTION.

p. 11, in description of presses, for hoop-iron, *read* iron rod, such as children's hoops are made of.

PART I.

p. 80, figs. 7, 8, the circles representing the stems should be at the top of the figures.

p. 169, line 27, for Mesophytes *read* **Mesophytes.**

PART II.

Aeginetia Linn. Orobanchaceae. 2 sp. Himal. to Japan and Phil. Is.

Aegle: *add A. Marmelos* Corr. is the bael fruit, cult. in the tropics.

Aizoon: *insert* Linn. after name of genus.

Alectorolophus Hall = Rhinanthus Linn.

Alkanna: after *tinctoria*, for L. *read* Tausch.

Alternanthera: *insert* (excl. *Mogiphanes* Mart.).

Amherstia: *add* the young shoots are pendulous (p. 157, and Keeble in *Ann. Bot.* IX. 59).

Amphicarpaea: after Japan *insert* China.

Anacampseros: *insert* Linn. after name of genus.

Archangiopteris Christ et Giesenh. Marattiaceae (I). 1 sp. S.W. Chi. Leaves once pinnate; sori linear, of 80—160 sporangia.

Arenga: for flowers once *read* flowers when mature, infls. appearing in descending order, till the tree dies after the last is ripe.

Artemisia: *insert A. Abrotanum* L. is the old man or southernwood of gardens. *A. tridentata* Nutt. and others form the sage-brush of the western U.S. (p. 188).

Astragalus: after falls off, *insert* (p. 20); for resin *read* gum.

Azadirachta A. Juss. = Melia L. *A. indica* A. Juss. = M. Azadirachta.

Baeria: *add* (excl. *Actinolepis* DC.).

Balanophora: *add* Some are apogamous (cf. Filicineae, and see Treub in *Ann. Buitenz.* XV.).

Balanops Baill. Balanopsidaceae. 7 sp. New Caled.

Balanopseae (Benth.-Hooker). Balanopsidaceae. An anomalous order placed in Unisexuales by Benth.-Hooker, now accorded a separate cohort (Balanopsidales) by Engler, between Myricales and Leitneriales.

Baphia Afzel. Leguminosae (III. 1). 12 sp. trop. Afr., Madag. *B. nitida* Afzel, the camwood, gives timber which yields a red dye (cf. Haematoxylon).
Brucea J. S. Müll. Simarubaceae. 5 sp. palaeotrop. Very astringent. The seeds of *B. sumatrana* Roxb. and others are old native remedies in dysentery.
Cactaceae: at end, after *Bot. Gaz.* 1895, insert *Ann. Bot.* 1898.
Cajanus: after As., *insert C. indicus* Spreng.
Callistephus: after aster, *insert* (see *Bot. Mag.* 1898, t. 7616).
Canavalia DC. Leguminosae (III. 10). 12 sp. trop., some cult. as beans.
Capparidaceae: at end, after Benth.-Hooker, *insert* (see Tovaria).
Carpodinus R. Br. Apocynaceae (I. 1). 12 sp. W. Afr. Rubber is obtained from the roots of *C. lanceolatus* K. Sch.
Caryocar: after seeds, *insert* of *C. nuciferum* L.
Chamagrostis Borkh. = Mibora Adans.
Cheirostemon: after the bracket, *insert* Sterculiaceae.
Chickrassia A. Juss. Meliaceae. 1 sp. Ind., Ceylon, *C. tabularis* A. Juss., with good timber (Indian red-wood, Chittagong wood, white cedar).
Chlidanthus: after Herb. *omit* App.
Citrus: after shaddock, *insert* pomelo or grape-fruit.
Cleome: *insert* (incl. *Polanisia* Rafin.).
Clitandra Benth. Apocynaceae (I. 1). 3 sp. trop. Afr. Rubber is obtained from the roots of *C. Henriqueziana* K. Sch.
Connaraceae: after 160 sp. *add* trop.
Contortae, (Engler) the third, (Warming) the seventh, cohort of Sympetala.
Corynocarpus Forst. 1 sp. N.Z., placed in Anacardiaceae by Benth.-Hooker, now given a separate order by Engler.
Crossosoma Nutt. 2 sp. S.W. U.S., placed in Dilleniaceae by Benth.-Hooker, now given a separate order next to Rosaceae by Engler.
Croton: after *Cascarilla add* (Florida, W.I.), and at end *add* The ornamental Crotons of trop. gardens are sp. of Codiaeum.
Cynomorium: *add* Sometimes placed in a separate order.
Cyphomandra: *add C. betacea* DC. is cult. in sub-trop. climates for its edible fruit (tree-tomato).
Daemia R. Br. Asclepiadaceae (II. 1). 6 sp. trop. As., Afr.
Daemonorops Blume = Calamus Linn.
Decaisnea: after Himal. *insert* China.
Delima Linn. = Tetracera Linn.
Diplospora DC. Rubiaceae (I. 8). 15 sp. trop. As., Chi.
Dipteris Reinw. Polypodiaceae. Incl. in Polypodium by Hooker, but very distinct. Cf. Seward and Dale in *Phil. Trans.* 194.
Dombeya: after Afr. *add* Madag.
Doona Thw. Dipterocarpaceae. 11 sp. Ceylon.
Dregea E. Mey. Asclepiadaceae (II. 4). 5 sp. Afr., As.

Elaterium: after Jacq. *omit* f.

Esenbeckia: after Rutaceae, for (2) *read* (v).

Eucommia Oliv. Trochodendraceae. 1 sp. China, *E. ulmoides* Oliv., yielding a medicinal bark used in China, and caoutchouc.

Fittonia E. Coem. Acanthaceae (IV. B). 2 sp. Peru. Leaves prettily veined.

Flaveria Juss. Compositae (VI). 6 sp. trop. Am., Austr.

Flemingia Roxb. (*Moghania* St Hil.). Leguminosae (III. 10). 20 sp. palaeotrop.

Funkia: for Aechornea *read* Alchornea.

Funtumia Stapf (*Kickxia* Blume, p.p.). Apocynaceae (II. 4). 5 sp. trop. Afr. *F. elastica* Stapf is the chief source of Lagos rubber.

Galphimia Cav. Malpighiaceae (II). 11 sp. trop. and subtrop. Am.

Genlisea A. St Hil. Lentibulariaceae. 10 sp. trop. Am., Afr.

Gentianaceae: the names of the sub-orders should be in italic capitals.

Gesneriaceae: the names of the sub-orders should be in italic capitals.

Ginkgo: this genus is better placed in an order to itself, and this order probably represents a class equal in rank to the other classes of Gymnospermae; cf. Seward and Gowan in *Ann. of Bot.* 1900, p. 108.

Glaux: for seeding *read* seedling.

Gmelina Linn. Verbenaceae (IV). 8 sp. Indo-mal.

Gomortega Ruiz et Pav. 1 sp. W. S. Am., left as of doubtful position by Benth.-Hooker, now placed by Engler in a separate order next to Myristicaceae.

Gonystylus Teijsm. et Binn. 1 sp. Malayan. Placed in Thymelaeaceae by Benth.-Hooker, now placed by Engler in a separate order in Malvales.

Hancornia Gomez. Apocynaceae (I. 1). 1 sp. Brazil, *H. speciosa* Gomez, the source of Mangabeira rubber.

Hopea Roxb. Dipterocarpaceae. 45 sp. Indo-mal.

Hydrilla Rich. Hydrocharitaceae. 1 sp. Eur., As., Afr., Austr.

Hydrobryum Endl. Podostemaceae. 5 sp. India, Ceylon. Thallus of root nature, creeping, often lichen-like with growing margin.

Ipomaea: *add I. biloba* Forst. (*I. pes-caprae* Sw.) is a characteristic creeping plant of trop. beaches (p. 191).

Kickxia: *omit* trop. Afr.; *add* (cf. Funtumia).

Lansium Rumph. Meliaceae. 4 sp. Indo-mal. *L. domesticum* Jack is cult. for its edible fruit.

Lawia Tul. Podostemaceae. 1 sp. Ceylon to Bombay. Thallus of shoot nature, creeping, with endogenous shoots on the upper side.

Leitneriales (Engler), a cohort lately separated from the Juglandales, only order Leitneriaceae.

Lilaea Humb. et Bonpl. Juncaginaceae. 1 sp. Am. Mts. (*Ann. of Bot.* XII. 98).

Limonium Tourn. ex Mill. = Statice Linn.

Liriope Lour. Liliaceae (VIII). 1 sp. Cochin-China to Japan.

Lodoicea : after largest *read* simple fruit.

Loxsoma Br. Hymenophyllaceae. 1 sp. N.Z., better placed in a separate order; cf. Filicineae, and Gwynne-Vaughan in *Ann. Bot.* XIV. 1901, p. 71.

Luculia Sweet. Rubiaceae (I. 4). 2 sp. Himal. The fruit of *L. gratissima* Sweet is edible.

Luisia Gaudich. Orchidaceae (31). 10 sp. trop. As., Jap.

Lumnitzera Willd. Combretaceae. 2 sp. trop. Afr., As., Austr., in mangrove swamps (p. 191).

Machilus Nees. Lauraceae (I). 15 sp. S. and E. As. Persea Linn. is sometimes merged in this genus.

Macodes Lindl. Orchidaceae (4). 1 sp. Java.

Magnoliaceae : *add* Benth.-Hooker add Trochodendraceae and include the order in Ranales.

Marantaceae : *add* The leaves sleep at night and in dull or wet weather by bending upwards at the pulvini (p. 49).

Marattiaceae : after large ferns, *read* with a rhizome or stout stem. And in classification, after Angiopteris *read* (sori of 10—20 sporangia), Archangiopteris (sori linear, of 80—160 sporangia).

Martinezia Ruiz et Pav. Palmae (IV. 7). 7 sp. trop. S. Am.

Mascarenhasia A. DC. Apocynaceae (II. 4). 10 sp. Madag., E. Afr. *M. elastica* K. Sch. yields caoutchouc.

Matonia Br. Cyatheaceae. 1 sp. Borneo and Mal. Penins., *M. pectinata* Br., an interesting survival of an ancient type, better placed in a separate family. Cf. Filicineae, and Seward in *Phil. Trans.* 191.

Melia : after *M. Azedarach* L., for Margosa *read* the bead-tree or Indian lilac. And *add M. dubia* Cav. (palaeotrop.) yields a valuable, very light, timber.

Melicope Forst. Rutaceae (I). 12 sp. Indo-mal., Austr., N.Z.

Melocanna Trin. Gramineae (XIII). 1 sp. Ind. Exalbuminous (cf. Stapf in *Nature*, Apr., 1902, p. 548).

Melodinus Forst. Apocynaceae (I. 1). 20 sp. Indo-mal., Polynes.

Metachlamydeae = Sympetalae.

Microlicia : after name of genus, *insert* D. Don.

Milla Cav. Liliaceae (IV). 1 sp. Mex.

Mimosa : *add* See Ewart in *Ann. Bot.* XI. 448; Nemeç, *Die Reizleitung und die reizleitenden Strukturen bei den Pflanzen*, Jena, 1901.

Mitrephora Hook. f. et Thoms. Anonaceae (V). 20 sp. trop. As.

Mollinedia Ruiz. et Pav. Monimiaceae. 30 sp. Am., Austr.

Montanoa Cerv. Compositae (V). 20 sp. trop. Am.

Montrichardia Crueg. Araceae (IV). 3 sp. trop. Am.

Mouriria Juss. Melastomaceae (III). 40 sp. trop. Am.

Mucuna : *add M. pruriens* DC. is the cowage or cowitch, a var. of which is the Florida velvet bean, a useful fodder.

Myricales (Engler), a cohort lately separated from Juglandales, containing the order Myricaceae.

Niphobolus Kaulf. = Polypodium Linn. Cf. Giesenhagen, *Die Gattung N.*

Noltea Rchb. Rhamnaceae. 1 sp. S. Afr.

Nyctanthes Linn. Oleaceae. 1 sp. E. Ind.

Odina Roxb. (*Calesium* Adans.) Anacardiaceae (II). 15 sp. trop. Afr. As.

Oncosperma Blume. Palmae (IV. 6). 5 sp. Indo-mal.

Oreodaphne Nees et Mart. = Ocotea Aubl.

Osyris Linn. Santalaceae. 6 sp. S. Eur., As., Afr.

Pangium Reinw. Flacourtiaceae (Bixineae, Benth.-Hooker). 2 sp. Malayan.

Papaveraceae: for $\underline{G}$ (2—8) *read* $\underline{G}$ (2—∞).

Parameria Benth. Apocynaceae (II. 4). 3 sp. Indo-china, Mal.

Parinarium Aubl. Rosaceae (VI). 35 sp. trop.

Parmentiera DC. Bignoniaceae (IV). 2 sp. Centr. Am. *P. cerifera* Seem. is the candle-tree, its long fruits resembling tallow candles; they are borne on the old wood (p. 190).

Passifloraceae: *add* Ct. Acharia.

Pentaphylax Gardn. et Champ. 1 sp. Chi., placed in Ternstroemiaceae by Benth.-Hooker, now given a separate order near Celastraceae by Engler.

Phanerogamae, see Spermaphyta.

Pharnaceum Linn. Aizoaceae (I). 16 sp. S. Afr.

Phytolaccaceae: *read* $\underline{G}$ (rarely $\overline{G}$).

Picraena Lindl. Simarubaceae. 8 sp. trop. *P. excelsa* Lindl. yields the bitterwood or Jamaica quassia.

Podostemon Michx. Podostemaceae. About 15 sp. S. Am., Ind., Ceylon.

Pollinia Trin. Gramineae (II). 30 sp. trop. and subtrop.

Porogamae, see Chalazogamae.

Prosopis: after name of genus *add* Linn.

Psilotaceae: after (Homosporous) *add* [Bower regards P. as belonging to the Sphenophyllales].

Pterisanthes Blume. Vitaceae. 12 sp. Indo-mal.

Putterlickia Endl. Celastraceae. 2 sp. S. Afr.

Puya Molina. Bromeliaceae (3). 5 sp. Chili, Peru.

Pycreus Beauv. = Cyperus Linn.

Rauwolfia Plum. ex Linn. Apocynaceae (I. 3). 45 sp. trop.

Ravensara Sonner. Lauraceae (II). 4 sp. Madag.

Rhinanthus: *add* Ct. Sterneck, *Monogr. d. Gatt. Alectorolophus*, in Abh. d. k. k. zool. bot. Ges., Wien, I. 1901.

Rhodoleia Champ. ex Hook. Hamamelidaceae. 2 sp. Java, Chi.

Rhynchosia Lour. Leguminosae (III. 10). 100 sp. trop. and subtrop.

Ribes: *add* The dried currants of commerce are really small grapes.

Sandoricum Cav. Meliaceae. 6 sp. Indo-mal.

Sansevieria: for cultivated *read* employed.

Saraca Linn. Leguminosae (II. 3). 8 sp. trop. As. The young shoots are pendulous, as in Amherstia, Brownea, etc. (p. 157).

Saurauia: *add* (Ternstroemiaceae, Benth.-Hooker).

Scheelia Karst. Palmae (IV. 7). 3 sp. trop. Am.
Schinus: after (resin) *add* and is largely cult. in S. Calif. for shade and ornament (pepper-tree).
Schrebera Roxb. Oleaceae. 4 sp. trop. Afr., As.
Scorodosma Bunge = Ferula Tourn.
Scytopetalaceae. An order of 2 W. trop. Afr. sp., near Sterculiaceae.
Selaginella: *add* Cf. Gibson in *Ann. Bot.* 1894, 96, 97, 1902.
Siphonia: *add S. elastica* Pers. = H. guianensis.
Sparmannia: *add* Cf. Mrs Scott in *Ann. Bot.* XVII. 1903, p. 761.
Spathoglottis Blume. Orchidaceae (15). 10 sp. trop. As., Austr.
Speirantha Baker. Liliaceae (VII). 1 sp. China.
Sphenodesme Jack. Verbenaceae (VI). 10 sp. Indo-mal.
Stachyuraceae: *add* [Placed in Ternstroemiaceae by Benth.-Hooker].
Statice (Tourn.) Hill = Armeria Linn.
Stemodia Linn. Scrophulariaceae (II. 8). 30 sp. trop.
Streblus Lour. Moraceae (I). 1 sp. Indo-mal.
Strobilanthes: *add* Many sp. occur gregariously in vast masses in the undergrowth of mountain forests in S. As., usually flowering simultaneously over large areas and then dying.
Stylidium Lour. (*Marlea* Roxb.). Cornaceae. 10 sp. As., Afr., Austr.
Tabebuia: for Bigoniaceae *read* Bignoniaceae.
Tamonea: for Melastomaceae etc. *read* = Miconia Ruiz et Pav.
Terniola Tul. = Lawia Tul.
Theophrastaceae (Engler) = Myrtaceae, suborder I.
Trapella Oliv. Pedaliaceae. 2 sp. Chi., Jap.
Tristania R. Br. Myrtaceae (II. 2). 20 sp. Mal., N. Caled., Austr.
Tristicha Thou. Podostemaceae. 3 sp. trop. The least peculiar of this order, with the habit of an "ordinary" water plant (p. 158).
Triuridales (Engler). A cohort lately separated from the Helobiae, and comprising the order Triuridaceae.
Tumboa Welw. = Welwitschia Hook. f. *T. Bainesii* Welw. = W. mirabilis.
Tydaea Dcne. = Isoloma Dcne.
Uncaria: *add U. Gambier* Roxb. (gambir) is a valuable source of tan in the Straits Settlements etc. (Kew Bull. 1889, p. 247).
Urceola Roxb. Apocynaceae (II. 4). 7 sp. Indo-mal. *U. elastica* Roxb. yields caoutchouc.
Vallota Herb. Amaryllidaceae (I). 1 sp. S. Afr.
Vangueria Juss. Rubiaceae (II. 11). 30 sp. trop. Afr., As.
Verticillatae (Engler). A cohort of Archichlamydeae, comprising the order Casuarinaceae.
Villebrunea Gaudich. Urticaceae (3). 8 sp. India to Japan. *V. integrifolia* Gaudich. yields a good fibre, like rhea.
Wikstroemia Endl. Thymelaeaceae. 20 sp. As., Indo-mal., Polynes.
Willughbeia: *add W. firma* Blume (Borneo) yields indiarubber.
Wissadula Medic. Malvaceae (II). 10 sp. Am., 1 trop. Afr., As.
Withania Pauq. Solanaceae (II). 5 sp. palaeotrop. and subtrop.
Wormia: *add* Several sp. show bud-protection by sheathing petioles.

PART III.

GLOSSARIAL INDEX OF ENGLISH NAMES, ECONOMIC PRODUCTS, TECHNICAL TERMS, SPECIFIC NAMES, ABBREVIATIONS, PREFIXES, ETC.

GLOSSARIAL INDEX OF ENGLISH AND OTHER NAMES, ECONOMIC PRODUCTS, TECHNICAL TERMS, SPECIFIC NAMES, ABBREVIATIONS, GREEK AND LATIN PREFIXES AND SUFFIXES, ETC.

ALL references to Part I. quote the page, the fuller reference being mentioned first, *e.g.* absciss-layer, 156, 53; all to Part II. quote the article, *e.g.* Acorn, *Quercus.*

A number of English and other names for plants are incorporated in the Index, though not mentioned in the text of Part II. Most of the technical terms commonly met with are explained in Part I., but a large number of less common ones are incorporated here and briefly explained.

Genera and species often receive their names on account of some very marked character, *e.g.* Eriodendron (wool-tree) or Acanthophyllum (thorn-leaf), littoralis (growing on the beach) or pusillus (dwarf). The chief prefixes and suffixes used in compounding names, and the commonest specific names have therefore been included. In many cases the meaning of the Latin name is obvious from its resemblance to an English one, and such cases have been omitted.

Abbreviations are included in the Index, including the standard abbreviations of authors' names placed as authorities after genera and species, *e.g.* Adans. (Adanson). Abbreviated titles of periodicals and other literature are intelligible by reference to pp. 214—6.

Descriptions of floral morphology in Part II. are largely given in the terms of Floral Formulae, explained on p. 84.

When the name of a genus or order is repeated in the article dealing with it, it is represented by the initial letter only, *e.g.* A. for Abies.

The following mathematical and other symbols are largely used throughout the book:

☿, hermaphrodite	$\pm$, more or less than
♂, male	$>$, more than
♀, female	$<$, less than
( ) enclosing P, K, C, A, or G, united or concrescent	$\perp$, at right angles to
∞, indefinite, numerous	$\parallel$, parallel to
$\times$, hybrid	$=$, equal to, merged in
§, section (of sp. or genus)	!, seen by author
	μ, micromillimeter, $\frac{1}{1000}$ mm.

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Nature. It is not necessary to recommend the perusal of the book to all interested in the subject since it is indispensable to them, and we will merely conclude by congratulating the Cambridge University Press on having added to their admirable series of Natural Science Manuals an eminently successful work on so important and difficult a theme, and the author on having written a treatise cleverly conceived, industriously and ably worked out, and on the whole, well written.

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Revue Scientifique. Nous ne pouvons entrer dans le détail; mais il est évident que M. Seward, praticien distingué lui-même, est très au courant des travaux des autres, il les cite et utilise abondamment; et ceci est fait pour inspirer confiance. Au total, son œuvre est appuyée sur des bases solides, et elle restera sans doute longtemps le bréviaire, le manuel de ceux qui veulent, non pas seulement s'initier à la paléobotanique, mais retrouver les renseignements qui sont épars dans des centaines de monographies qu'on a souvent peine à se procurer. Le livre de M. Seward fait partie des *Cambridge Natural Science Manuals*, et il est digne de cette collection, qui est elle-même digne du foyer scientifique universellement réputé, où il a vu le jour.

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